Acid Deposition Research Program

NEWS RELEASE

June 21, 1984

Research and communications proposals released

CALGARY--Proposals developed at three major workshops were released today by the Acid Deposition Research Program (ADRP), an $8 million study of the effects of acid-forming emissions (such as sulphur and nitrogen oxides) on the Alberta environment. The proposals were released as a book entitled **Researching Acid Deposition: Workshop Proposals.**

This is the first major publication for ADRP, a research project jointly funded by the Alberta Government, the petroleum industry and three electrical utilities.

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At the program's two scientific workshops--held in September 1983 and January 1984,--scientists from across North America and Europe designed research programs to resolve the unknowns.

The first of the two workshops considered the impacts of acids on the biophysical environment--for example, agriculture, wildlife and Alberta's water systems and forests; the second, their effects on human health. Resulting from these workshops were two sets of research proposals which emphasize a multi-disciplinary approach toward the necessary research.

Because of public interest in acid-related issues, ADRP sponsors felt that a public involvement and communications workshop should be held to determine effective ways to inform the public about the program, its objectives and research results. Accordingly, in late April ADRP convened communications specialists from public interest groups, industry and government to develop a communications plan which could effectively share program information with the public.

Each workshop prepared written proposals for an effective communications program. The three written statements are reproduced in the ADRP publication.

To implement all of the proposals received would require more money than the research program has available. Because of budgetary constraints, therefore, the program's Members Committee (ADRP's governing body) will need to be selective in its funding approvals.

To ensure public input to the program's decision-making process, **Researching Acid Deposition: Workshop Proposals** is being sent to Alberta's principal environmental groups, to the major media, to municipal and rural libraries, and to other interested parties.

Additional copies are available from Alberta Environment and the Canadian Petroleum Association.

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Acid Deposition Research Program

RESEARCHING ACID DEPOSITION: WORKSHOP PROPOSALS

Because of budgetary constraints, the research plans proposed in this document cannot be undertaken in their entirety. The ADRP Steering Committee will therefore need to be selective in its funding approvals. It should also be noted that not all the views and opinions expressed in this document accurately reflect the views and opinions of ADRP sponsors.

Public comment is invited, but must be received at ADRP offices by August 1, 1984 to influence program development.

This report is published by the Acid Deposition Research Program, 1536, 630 6th Ave. S.W., Calgary, Alberta T2P 2S8, (403) 292-4232.

Preface

In April 1983, the petroleum industry and the provincial government announced a joint research initiative, the Acid Deposition Research Program (ADRP). This major program has been designed to help meet the need for a fuller understanding of acid deposition and its effects on the Alberta environment.

The ADRP will undertake a long-term assessment of the environmental impact of acid-forming gases in Alberta. At a cost of $8 million over seven years, the program is the most ambitious ever developed in Alberta. Sponsors include the Alberta government; the Canadian Petroleum Association; the Independent Petroleum Association of Canada; NOVA, An Alberta Corporation; Petro-Canada; and Alberta's three principal electrical utilities. The commitment to undertake the research was formalized in March 1982.

The program will commission specific acid gas-related studies, publishing and disseminating interim reports to the public as research progresses. Research will focus on two principal gas groups: oxides of sulphur (SO_x) and oxides of nitrogen (NO_x): ADRP will commission studies into the generation, transformation, transportation and deposition of these and other minor gases. A major report outlining the program's finding, conclusions and recommendations will be released at the conclusion of the project.

Although research on acid-forming emissions has been conducted by both industry and government for decades, ADRP is the most comprehensive study by far. Research results cannot be predicted, but there is little doubt that the program will extend the body of scientific knowledge about the impacts of acid deposition, perhaps contributing toward global solutions to this environmental concern.

A distinctive feature of ADRP is an approach which will develop and fund research in two major areas. A biophysical research program will investigate the impact of acid deposition on vegetation, soils and water; a medical research program will look into the effects on human health.

Despite the fact that Alberta's industrial emissions regulations are among the world's most stringent, public concern persists about the possible impact of emissions on air, water, land and human systems. The Acid Deposition Research Program proposes to determine and clarify the justification for public concern, and where possible, to identify solutions.

To ensure top calibre scientific design and impartiality, ADRP invited internationally-recognized scientists to two task-oriented workshops. These preliminary workshops, held to establish a work plan for the extended project, have drawn on the best expertise available.

The purpose of the workshops was to develop a multidisciplinary approach to the study. As the following documents make clear, both the biophysical and human health research committees voiced their commitment to this approach. The biophysical researchers held their workshop in October 1983; the human health researchers, in January 1984. Their proposals have been reproduced here as they were presented to the sponsors, without editorial changes.

In addition to the two scientific workshops, ADRP sponsored a communications workshop in April 1984. Because of high public interest in acid-related issues the sponsors felt it was essential to incorporate public involvement and communications into ADRP activities.

This volume, ADRP's first major publication, is thus the result of considerable and concerted effort to come to terms with issues of increasingly high profile. It will guide ADRP as it commissions research in the years ahead and as it reports the results of this research to the people of Alberta.

But it is not the last word on the program, either. Because the research proposed at the two workshops would cost considerably more than the $8 million which has been allocated to this program, it will be necessary for ADRP to be selective in the research proposals it agrees to fund.

Moreover, since the public involvement and communications workshop stressed the need for public comment on ways and means for Alberta publics to be informed on the program, before the sponsors decide upon a final communications package they have agreed to first solicit public input. This publication offers ideas on a communications package which — like the research plans — are not the final word.

Acknowledgements

This publication should not go to press without recognizing the volunteer efforts of a large number of capable and dedicated individuals. The Alberta government's co-chairman for ADRP's first year was Alberta Environment's Jerry Lack.

Co-chairmen of the biophysical workshop were Dr. Sagar Krupa of Alberta Environment (currently with the University of Minnesota) and Dr. Dennis Parkinson of the Kananaskis Research Centre. Their counterparts at the human health workshop were Dr. Dave Chisholm of Shell Canada Resources and Dr. Bob Rogers of Workers' Health, Safety and Compensation.

Co-chairmen of the public involvement and communication workshop were the Canadian Petroleum Association's Peter McKenzie-Brown and Alberta Environment's Chris Staddon.

Representing Alberta's many environmental groups as the members committee began to grapple with issues of public involvement was Rocky Mountain House veterinarian Dr. Martha Kostuch. Offering valuable and informed opinion from the Energy Resources Conservation Board was Ed Brushett.

Other Members Committee members were Bill Ross, Esso Resources Canada; Dr. Percy Sims,

Alberta Environment; Jock Poyen, the Independent Petroleum Association of Canada; Mike Robertson, Petro-Canada; Phil Mason, NOVA, An Alberta Corporation; and Dr. John Railton, TransAlta Utilities. Serving as secretary to the Members Committee was Dr. Harby Sandhu, Alberta Environment.

For the efforts of these and other colleagues who have contributed unstintingly to the success of the program, we express our warm and sincere appreciation.

Ron Findlay,
Manager Environmental Affairs
Amoco Canada Petroleum Company Limited;
Co-chairman

Ken Smith
Assistant Deputy Minister
Alberta Environment;
Acting Co-chairman

June 1984

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Introduction

A. Background

The ADRP is an idea whose time has come. Its realization, however, is due to the efforts of many individuals over a period of approximately five years. Those efforts were characterized by a strong and steady sense of purpose.

Initial impetus to the program came from the Alberta Petroleum Industry Government Environmental Committee (APIGEC), formed in 1972 and composed of representatives from Alberta Environment, Energy Resources Conservation Board, Energy and Natural Resources, and the Canadian Petroleum Association.

In the fall of 1979, APIGEC formed the Steering Committee on Acid Gases in the Environment (SCAGE). Its mandate was to develop a coordinated research program to determine the consequences, both positive and negative, of acid deposition in Alberta. In formulating its recommendations, the Committee would have to address the concerns of the petroleum industry, the power industry, the provincial government, and the public. Recruiting about 40 experts form Alberta's industry, government and universities, SCAGE created three technical subcommittees to deal with acidification effects on environmental systems and human health.

The subcommittees were to review existing research information on acid-forming emissions. In addition, they would determine the extent of knowledge deficiencies and recommend appropriate research projects, while emphasizing the development of an ecological monitoring strategy for maintaining long-term environmental quality in Alberta.

In 1981 SCAGE submitted its report to APIGEC. The underlying and most important feature of the report was its holistic approach to problem-solving: Its basic assumption was that all components of ecosystems are interrelated. Thus it is only by understanding chemical and biological processes within, between, and among ecosystems that researchers can hope to assess the impacts of acid deposition.

According to report recommendations, the research plan should involve basic information requirements in terms of acid-forming emission sources (gas plants, compressor stations, oil sands plants, refineries, power plants, natural background emissions), their transportation paths, and their ultimate effects on ecosystems and human health. In order to address such a complex environmental problem, a coordinated and interdisciplinary approach, with specific disciplinary talents working together, was deemed essential.

The SCAGE report led to the development of the Acid Deposition Research Program. The ADRP adopted and maintained this early emphasis on holistic research design. Although base research data is presently limited, particularly in the area of animal and human health effects, the ADRP will go a long way toward rectifying this situation. Indeed, that is part of its mandate. The final synthesis of the research program will then be able to address the fate, form, and effect of acid-forming gases under various environmental conditions, both in the short and the long-term.

The Acid Deposition Research Program is ambitious in the best sense of the word. Its aims are to clarify the effects of acid deposition in order to protect all of Alberta: its industry and agriculture, its wide open spaces and its people.

The remainder of this introduction provides a detailed description of ADRP, its objectives and major organizational features. The reader will perhaps forgive duplication of some of this introductory material in the three major sections which follow. In order to preserve the integrity of the workshop proposals in their original form, all three are presented without editorial changes.

B. Acid Deposition Research Program Objectives

1. Provide a comprehensive understanding of the effects and consequences of acid-forming gases on the environment;
2. Provide a scientific basis for sound, long-term environmental management and regulatory control with respect to acid-forming gases;
3. Disseminate such information among members, to the public and to government bodies;
4. Undertake any research deemed appropriate.

C. Membership and Percentage Participation

Initial Members	Percentage Participation for Voting and Funding	Number of Voting Representatives	*Number of Non-voting Representatives
The Minister	50.00	1	2
Canadian Petroleum Association	34.20	1	1
Independent Petroleum Association of Canada	5.27	1	—
Utilities Group - TransAlta Utilities Corporation** - Alberta Power Limited - The City of Edmonton	5.27	1	—
Petro-Canada Exploration, Inc.	2.63	1	—
Nova, an Alberta Corporation	2.63	1	—
Energy Resources Conservation Board	—	—	—
Public Member	—	—	—
TOTAL	100.00%	6	3

* Any member having more than 20% participation shall be entitled to one non-voting representative; more than 40%, two non-voting representatives, more than 60%, three non-voting representatives.

**Member company of group.

NOTE: See "Members committee Representatives" listing on last page for names of specific members.

D. **Organization**
See Chart, p.58, for current organization and proposed changes.

E. **Responsibilities of Members Committee**

1. The terms, conditions, and intent of the Agreement are carried out under the Charter under the direction of a "Members Committee."
2. The Members Committee generally supervises and has overall control over operations.

F. **Decision Making - Members Committee**

1. Except for the expulsion of representatives, all matters are decided by at least a 90 percent affirmative vote of the voting representatives of the total Members.
2. The voting interest of each member is in direct proportion to the percentage participation of each Member.

G. **Responsibilities of Executive Committee**

1. Recommending a program of research to be conducted over the term of the Agreement;
2. Preparing prior to June 1 of each year an annual budget for the next fiscal period and a forecast of expenditures for the term remaining in the current fiscal period;
3. Preparing prior to October 31 of each year a semi-annual update of the annual budget of the next fiscal period; and
4. Preparing prior to June 1 of each year an annual report of research activities carried out under this Agreement.

The budgets and reports are referred to the Members Committee for approval. Following approval, the Executive, within 30 days reviews the annual report with the Alberta Petroleum Industry Government Environmental Committee (APIGEC).

The Members Committee can, at its discretion, delegate to the Executive any powers of the Members Committee subject to such restrictions as may be imposed from time to time by the Members Committee; and provided always that the Executive is subject to the direction and control of the Members Committee.

H. **Decision Making - Executive Committee**

Each member of the Executive has one vote and issues are to be decided by a simple majority.

I. **Project Management**

No final decisions have been made in this area.

J. **Technical Research Committee - Biophysical**

(i) Membership
Government Co-Chairman:
Dr. Sagar Krupa
Alberta Environment - (Since resigned)
Industry Co-Chairman:
Dr. Dennis Parkinson
Kananaskis Science Centre
University of Calgary

(ii)Terms of Reference

1. To assist in the initial planning of the research program by:

- Identifying the major issues relevant to short and long term effects of acid-forming emissions on ecosystems;

- Describing a holistic approach to assess and predict the impacts of acid-forming emissions on Alberta ecosystems;

- Defining an integrated (Air-Vegetation-Soil-Water) research program to assess and predict the short and long term effects of acid-forming emissions on Alberta ecosystems.

2. To evaluate program proposals submitted by potential contractors prior to initiation of the research program.
3. To serve as a peer review team -

- During the course of the 5-year research period;

- Following submission of the final research program report.

K. **Technical Research Committee - Human Health**

(i) Membership
Government Co-Chairman:
Dr. R. Rogers
Workers Health & Safety & Compensation
Occupational Health Services

Industry Co-Chairman:
Dr. D. Johnston
Dome Petroleum Ltd.

Additional Members:
Dr. D. Stokes
Alberta Environment
Dr. D. Chisholm
Shell Resources Canada

(ii)Terms of Reference

"To assist in the planning of an integrated research program on acid-forming emissions by:

a) identifying major issues relevant to short and/or long-term effects of acid-forming emissions on humans.

b) defining a comprehensive research strategy that can be used to quantitatively or qualitatively assess the effects of acid-forming emissions on human health.

c) integrating in a holistic manner the human research strategy with essential biophysical strategies to assess or predict the impact of acid-forming emissions on human health."

Alberta Government/Industry
Acid Deposition Research Program

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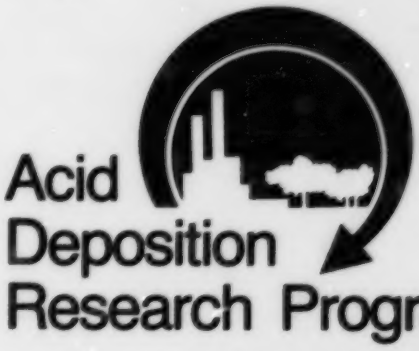

BIOPHYSICAL WORKSHOP

September 1983

1. Executive Summary

This document describes a comprehensive, integrated research program on the emission, dispersion, deposition, and ecological effects of acidic and acidifying pollutants. The program emphasizes the need for close collaboration among investigators from many different scientific disciplines.

The proposed program will extend over a five-year research phase, after an initial period of study site(s) identification and methodology development. In this initial period, a critical focus will be on implementing the multidisciplinary framework required to form a coherent program from components representing specialties in air quality, vegetation effects, soil effects, and aquatic effects. Most of these specialties are represented in the Alberta environmental research community, and this is seen as a factor likely to contribute strongly to the success of the overall program. To a considerable extent, the success of this program depends on the ability to bring these existing skills together in a manner that will assure coordinated direction toward the jointly-recognized goal of an essentially holistic program. The development of an integrated transport, deposition, and effects model is seen as a goal of this program, with model subroutines constituting individual targets for research in the separate disciplines. The detailed structure of such a model is not specified but is seen as an important first goal of the initial work under this program.

The program also calls for an additional one-year period for final data analysis, synthesis, and report preparation.

The opportunities available in Alberta for this kind of work combine to make studies of environmental impact especially attractive. The ready availability of much of the required expertise is not the only reason for identifying Alberta as an especially advantaged experimental location. The province appears to be exposed to relatively clean incoming air which is modified by emissions from sources which are already well documented and regulated. The research interest and joint-active involvement of Alberta industry and government is an especially welcome and critical feature. Finally, the size of the province is such that many potential experimental locations can be identified, from which suitable candidates should be easily selectable.

Sites for effects work should also be sites for air quality, precipitation quality, and related meteorological investigation. Data obtained should be adequate for inferring time-varying surface fluxes of the pollutants deemed to be of greatest importance (e.g., SO_2, NO_x, and O_3). The surface fluxes, or dry deposition rates, form a direct link between air concentrations and pollutant uptake rates. Only slightly less direct is the link between effects and components brought down by rain and snow. Dose/response models presently under development are starting to take the time-varying nature of atmosphere/canopy interaction into account. The present program is designed to provide the data required by this new generation of dose/response models as well as the longer-term averages needed by older (but still more conventional) approaches.

Air quality and source characterization data bases generated during the study will serve as input to source apportionment techniques to determine the sources of the chemical species that impact the Alberta ecosystems. Air quality (and precipitation quality) data will also be obtained on a regional basis, to provide documentation of the background characteristics in which the effects studies are conducted. This information will also assist in separating regional versus local emissions, to inflow of pollution across upwind provincial boundaries, and to export downwind.

A key component of the proposed research plan is to conduct vegetation effects studies at a small number of well-instrumented sites selected to provide a range of pollutant-exposure conditions under natural circumstances. Studies of effects in conditions of natural exposure should be accompanied by open-top chamber studies at one of these sites, thus providing independent information on dose/response relations at the same location. The focus of these studies would be on both forests and crops, although it is clear that chamber studies are most applicable in the latter case.

Soil studies will be conducted in concert with the investigations of vegetation effects. Soil samples will be exchanged among the sites selected for vegetation studies. The emphasis of biological effects studies will be on soluble species in the soil, on soil microbiology, and on root biomass.

Aquatic research will look for evidence of decreased pH and increased levels of potentially toxic metals. The potential sensitivity of aquatic receptors will be assessed, and if alkalinity gradients are evident, the contribution of atmospheric acid deposition will be determined by analysis of observations made in conditions of different acid loading.

The probability of success of the research plan set forth here is dependent on the degree of integration achieved in its management. It cannot succeed if it is separated into independent, uncoordinated sectors. It should be initiated as a single project with a single prime contractor who will submit a single, integrated proposal. The contractor can and should bring in appropriate research scientists or research groups from outside the contractor's own organization to provide specific skills and/or execute specific components of the total program. However, the prime contractor must retain authority, responsibility, and accountability for the entire project, and for synthesizing all components into a holistic view of the data and analysis in the final report.

2. Introduction and Objectives

For the past several years significant concern has been expessed regarding the present and potential effects of the atmospheric inputs of acidic and acidifying substances on the environment. Because of these concerns, the Alberta government and industry developed a joint committee to address environmental issues. As part of its activities this joint committee initiated an Acid Deposition Research Program. This Alberta Government-Industry Research Program consists of two major components:

1. biophysical research
2. human health effects research

The attached document pertains only to the biophysical research component.

In the present context the biophysical research concerns air, land, and water. In addressing these components in a holistic and integrated way, eminent scientists, in the appropriate disciplines, from outside Alberta were invited to participate in a workshop held in Calgary (12-16 September 1983).

Selected Alberta scientists were also invited to participate in the workshop to provide local resource information.

The attached document provides an integrated research plan to answer the following questions:

1. What are the short and long-term effects of acid-forming substances on Alberta ecosystems?
2. What is the significance of the observed or predicted effects?

The document represents the consensual opinion which has been verified by each of the non-Alberta scientists.

3. Recommended Research Plan

The unique air quality situation of the Province of Alberta, and the scientific capabilities already present in a wide variety of environmental disciplines, combine to provide an unequalled opportunity to conduct a comprehensive, integrated program of air quality modification and consequent environmental effects. Five distinct but closely interacting components of this comprehensive program have been identified: (a) Air Quality Effects; (b) Vegetation Effects; (c) Soil Effects, (d) Aquatic Effects, and (e) Integration and Simulation. The importance of the last-named activity is extreme; it is seen as the glue binding together the specialties contributing to each of the other components. In discussion of each part, scientific needs are tabulated and scientific approaches by which these questions can be addressed are discussed.

3.1 Air Quality Studies

3.1.1 *Introduction*

There is a need to consider questions of air quality at several different levels. Clearly, there is a need to relate Alberta industrial emissions to natural emissions and to the background air quality of the geographical region in which the province is located. Moreover, the environmental consequences of this modified air quality must be considered through effects of both primary and secondary pollutants (secondary pollutants are formed by chemical reactions in the air, involving actual emitted species, usually gaseous). Studies of air chemistry and its effects are not necessarily sufficient since precipitation quality will also be modified (by a largely unknown amount) by Albertan emissions; hence precipitation-related studies must also be considered. These factors are summarized in Table 3.1.1 as a list of scientific needs, corresponding to questions considered to be of sufficient importance that answers should be sought in this program.

A common feature of the issues identified in the list of recognized scientific needs given below is the requirement for improved air quality (and meteorological) monitoring. Data are needed not only on concentrations of pollutants suspected of having direct ecological effects, but also on those airborne trace gases and aerosols that can help researchers understand the origins of the adverse air quality (and impacts) that they observe.

A second aim of this component of the plan is to provide information suitable for deriving dry deposition fluxes at sites selected for biological effects studies. In this instance, air quality data need to be collected using sensors with a response sufficient to resolve the dry deposition maxima associated with pollution episodes. For this purpose, real-time pollution monitors are required, supported by meteorological sensors selected to provide a basis for inferring pollutant uptake rates from the air concentration data.

Table 3.1.1
Scientific Issues Addressed by the Air Quality Component.

1. Document background composition of air flowing into Alberta and background precipitation quality.
2. Assess industrial point-source emissions in Alberta:
   (a) of trace gases likely to have direct biological consequences (SO_2, H_2S and NO_x, primarily).
   (b) of aerosols and trace metals of assistance in interpreting air quality data.
3. Assess mobile and area (including natural) sources, especially associated with:
   (a) cities
   (b) bogs, and
   (c) agricultural practices.
4. Determine exposure regimes resulting from these emissions. Questions arise about the mechanisms of transport and atmospheric transformation, wet and dry deposition, the distances involved, the locations of major influence, and transport into neighboring jurisdictions.

5. Identify sites suitable for studies of biological effects, taking into account the local air quality regime, vegetation species, terrain, meteorological conditions, and access.
6. Develop methodology suitable for evaluating pollutant uptake rates at receptor sites, from air quality and meteorological data.

3.1.2 *Air Quality Monitoring*

The required analytical and monitoring program must focus on emissions related to Alberta industry. The major emission species of concern are H_2S, SO_2, NO_x, and elemental sulphur. Also of importance are O_3, organics and aerosol composition. Ozone data should be required because O_3 has been identified as a co-factor in vegetation effects; organics are measured since they can be mutagenic and/or carcinogenic to humans and animals; and aerosols contain a wide range of species that aid in tracing air masses. Aerosols also affect visual air quality and contribute to the acidity burden to an ecosystem.

Although much of the present program concentrates on direct air quality impacts and environmental effects, attention must also be given to precipitation quality. Wet deposition should be measured at all monitoring sites, both to assess the role of precipitation as a sink for Alberta emissions and to provide an experimental data base on precipitation quality for use in studies of related environmental effects.

3.1.3 *Background Air Quality*

To relate observed air quality conditions (and modification to "best-case" situations), it is necessary to monitor the composition of the air and precipitation entering the Province of Alberta from the outside. This "background air quality" is by no means constant; air from parts of the United States will have a different composition from air from British Columbia, and both will differ from air from the Northwest Territories. In addition, individual sources will give rise to variations in composition of air from each of these three major areas.

Accordingly, a fixed station should be located near the British Columbia border, representing the most frequent source area of influent air, supplementing this and assessing its representativeness by periodic measurements using mobile ground units and aircraft. Substances measured should be the same as those measured at the effects sites, although it is probably not necessary to measure with as great a time resolution: nitrogen oxides, sulphur dioxide, ozone, and the composition of particulate matter in at least two ranges of particle size. In addition, "state-of-the-art" wet and dry deposition samplers should be used.

Table 3.1.2 summarizes the measurement program and lists species that should be measured.

Table 3.1.2 Air Quality Monitoring Requirements

Issues	Species	Frequency	Methodology*	Rationale
1. Background Air Quality (a) Region-Related Background Site	SO_2, NO_x, O_3, Fine vs. coarse aerosol composition	• Integrated aerosol sampling (24 hours) • SO_2, NO_x, O_3, Real Time	• Elemental composition of size-fractionated aerosols • Gas measurement instruments	Elemental composition provides data base to determine origin
(b) Source-Related Control Site	SO_2, NO_x, O_c, Fine vs. coarse particles and rain sampling	• Integrated aerosol sampling (24 hours) • SO_2, NO_x, O_3 Real Time • Event rain sampling	• Elemental composition of size-fractionated aerosols • Gas measurement instruments • Rain sampling instruments	Data base provides information relevant to the specific source selected for study
2. Alberta Sources (a) Anthropogenic	SO_2, NO_x, S, Particulate matter representing source signature and emission rates	SO_2 - Continuous NO_x - Continuous	• In-stack measurement systems used to monitor SO_2, NO_x • Particulates collected by dilution sampling in two size fractions	Source characterization provides data base for source apportionment phase of program
(b) Area	(1) H_2S, RSH, NO_x, NH_3 case studies (2)	Short intensive studies Area Mobile - SAM emission inventory	C, FPD, Integration for NO_x NH_3	Provides data for natural natural sources
3. What are exposure regimes resulting from (1) and (2)				
• How distant will emissions be transported	SO_2, NO_x, SO_4, S, H^+ elemental composition	Continuous at 2 downwind sites	Use existing emission inventories	Predictive air quality modelling prior to study
• What does Alberta export • Where is air quality major effect • Where is wet deposition major impact	SO_x, NO_x10, Particles	Use all air quality data collected during study as input to receptor and dispersion models	Receptor modelling Predictive air quality modelling prior to study Sequential sampling at distant receptor	Results of modelling provides Alberta with necessary data to assess impact of industrial activities on neighbouring provinces

* All measurements should be made from fixed monitoring sites located at both background, control and receptor sites. For certain intensive periods instrumented aircraft should be used to obtain background and plume samples. Mobile laboratories may also be used to measure emissions from area sources.

It should be noted that all monitoring activities should include a meteorological measurement component, designed to provide first-order approximations to horizontal fluxes of the pollutants in question. The meteorological data set should thus concentrate on wind, speed and direction, and on precipitation, with supporting radiation, temperature, and humidity measurements to assist in interpreting air quality data. Siting criteria are discussed later.

Table 3.1.2 shows the parameters which should be monitored during the course of this research. It is recommended that the monitoring program should use the most advanced proven technologies. The technologies which should be assessed are:

1. tracer technology including tetroons
2. air mass marking and three dimensional trajectory methods
3. aircraft based measurements
4. chemical species measurements — to include aerosols, and gaseous and aqueous-phase species
5. dry deposition measurements
6. photography and other optical techniques.

3.1.4 *Industrial Emissions Inventory*

An inventory of point sources and annual emissions of SO_2 already exists for the Province of Alberta. For dispersion and receptor modelling it will be necessary to know the source conditions (stack height, exit temperature, exit speed, exit diameter, etc.). Such information is available but is not listed in a single compilation. During field work the temporal variations in source conditions should be recorded. This includes the operation of emergency and field flares.

In contrast with the case of sulphur emissions, data on emissions of nitrogen oxides are sparse and, at best, approximate. Available numbers are almost entirely based on "emission factors" obtained elsewhere and of unproven pertinence to local conditions. It is known that automotive emissions (as one example) are strongly influenced by air temperature, pressure, and humidity, yet such factors are rarely used to adjust calculated total emissions. Direct measurements of emissions of nitrogen oxides, including initial ratios of NO_2 to NO, are needed for at least the major individual point sources. Area sources, such as the major cities, should be critically examined to see whether updated inventories are needed.

Mathematical receptor models of several varieties are presently in use. All require source "signature" and ambient air quality data, including a set of particulate elemental composition data in the two dominant size regimes (larger than and less than about 2.5 μm diameter). Receptor models are distinguished from conventional dispersion models in that they start with observed concentrations based on knowledge of the compositions of different sources. For this reason, trace metal source signatures are required. Because of the apparently unique $^{34}S/^{32}S$ ratios in sour gas emissions, special attention should be given to the sulphur isotopic ratio in selected samples.

3.1.5 *Area Sources*

Two major categories of area sources can be distinguished.

The first of these are urban areas. In addition to such major pollutant sources as factories and power plants, cities contain a wide variety of minor sources, such as stoves, fireplaces, automobiles in great numbers, restaurants, dry cleaners, etc., each of which contributes some pollutants. No one source stands out, yet the aggregate of all sources can be very large. The result is a broad "urban plume" that can, on occasion, be traced across the landscape for hundreds of kilometres. It can have a major impact on air quality at substantial distances. Accordingly, at a minimum, good and current estimates must be made of the emissions from the generalized urban area. These can be checked by comparing the modelled impact of the urban plume with a limited number of air quality measurements at selected locations. It is necessary to examine present emission inventories for the major cities of Alberta, make judgements as to their accuracy, and update them where necessary.

The second category of area source comprises a variety of non-urban sources, and here two subcategories can be distinguished. To date these have been studied little, and their assessment, at least in rough terms, should be part of any thorough study.

The first group of non-urban sources are natural ones. Gaseous sulphur compounds, primarily H_2S, but also dimethyl sulfide, are produced by bacterial action on sulphur compounds in soils and water under some (not fully understood) conditions. In the atmosphere these compounds are converted into SO_2 and other acidic substances. The present evidence suggests that concentrations of these compounds are low. On the other hand, if their sources are extensive, the total sulphur that they move from the land surface into the atmosphere could be appreciable. Similar reasoning can be applied to nitrogen oxides. Also, O_3 is both produced from natural precursors in the lower atmosphere and episodically brought down from the stratosphere.

The contribution of natural O_3 has been studied and can be accounted for by sampling immediately upwind of the local sources under investigation. Natural contributions of sulphur and nitrogen compounds have been little studied, and doubtless vary with latitude, season, and perhaps even atmospheric pressure. Accordingly, a limited exploratory study should be planned to gain insight into a relative magnitude of such sources to permit a decision as to whether they need to be further characterized. If they are trivial they can be ignored thereafter. If they are not trivial, adjustments must

be made in the experimental design to include their explicit inclusion in source apportionment and in predictive models.

The second group of non-urban sources includes pollutants arising from agricultural practices. If soil bacteria mobilize sulphur and nitrogenous gases from natural soils, they may liberate still higher concentrations from heavily fertilized soils. This question must be studied by the same means used for natural emissions. Less questionable are particulate emissions from wind erosion of tilled soils, and these can be important. However, they have been studied, and are relatively easily characterized.

Nearly all these non-urban emissions can be expected to vary seasonally, and this will dictate that sampling programs, where needed, must also occur in appropriate seasons. Agricultural emissions will probably peak during and immediately following tillage and fertilization. Natural soils probably emit more gases shortly after the spring thaw and conceivably at times of falling atmospheric pressure. Emissions from ponds and lakes may be at a maximum in early summer when solar warming upsets their normal thermal structure. It would be desirable to plan intermittent visits to a number of sites on a rotating basis during the exploratory phase before concluding that any of these source classes were truly negligible.

3.1.6 *Modelling*

This portion of the report describes the role of mathematical air quality models in understanding and estimating the various atmospheric processes starting with emissions to the atmospheric from natural and anthropogenic sources and leading up to the presence of several acidic and acidifying substances in the atmosphere. In addition, these models are used to estimate the deposition of these substances from the atmosphere to the underlying receptors such as vegetation, soil, or water bodies.

The air quality models solve mathematical equations for concentration of chemical species in the atmosphere and are characterized in terms of:

1. temporal scale
2. spatial scale
3. transport mechanism
4. chemical transformation (reaction)
5. removal mechanism — both wet and dry

The existing air quality dispersion models can be applied to spatial scales ranging from local or short scales (a few km) to large scales (hundreds of km). Table 3.1.3 shows the model types used with different spatial ranges.

Generally, the Gaussian plume model is suitable for short-range calculations except when the terrain is characterized by hills and other complex topography. The temporal scale of air quality models ranges from hourly/daily to monthly/seasonal/annual. Again, Gaussian plume, trajectory and particle-in-cell models are quite suitable for short-term applications. Detailed discussions about the existing air quality dispersion and deposition models are included in Appendix 1. These discussions describe the "state-of-the-art" with regard to model characteristics, types of models, modules for simulating transport, chemical transformation, wet deposition, and dry deposition processes. The appendix also describes the status of the models as operational tools, their data requirements, and methodology to test model performance and uncertainties.

Table 3.1.3
Model Types and Associate Ranges

Spatial Range	Model Type
Short (<10)	Gaussian plume Trajectory Particle-in-cell
Intermediate (10-100)	All of above plus grid type
Long (>100 km)	Trajectory Grid Box

The movement of emitted material from sources to receptors involves both atmospheric transport and chemical transformation processes. The transport process is controlled by meteorological conditions such as wind direction and speed, and turbulence in the vicinity of the underlying surface.

Chemical transformation processes account for the chemical and physical changes in some of the precursors into acidifying species that ultimately result in the deposition of atmospheric acid matter. For example, primary air pollutants such as SO_2 undergo reactions in the atmosphere to form the secondary pollutant SO_4 which, in the presence of moisture (precipitation), appears as H_2SO_4 or other sulphates at the earth's surface. Most of the exciting models use a very simplified empirical approach for calculating chemical transformation processes. Also, while most models treat emissions of only sulphur oxides, there are a few models which have attempted to develop modules for nitrogen oxide transformation. In general, the type of chemistry module is determined by the intended application of a model. For example, if only source-receptor relationships for total sulphur are required, then chemical transformations involving sulphur compounds are important only to the degree that they affect removal processes. However, if knowledge of acidity is important, then a number of important reactants and reactions involving in a broad range of sulphur and nitrogen compounds ought to be included in the model formulation.

Existing pollution models simulate mechanisms in the atmosphere by using wet deposition and dry modules. Wet deposition has been calculated in terms of the precipitation rate, but this in itself is highly variable and non-uniformly distributed in space and time, especially during convective situations. Furthermore, the acid content of the air

in which precipitation forms and falls is equally variable. Therefore it is difficult to characterize rainfall rate on a scale adequate to describe the fate of a plume in its early stages.

Dry deposition rates of gases and particles are calculated by using a deposition velocity that is a function of land-use types (and therefore, season) and temperature distribution. It must be emphasized here that calculation of dry and wet depositions by the existing models is approximate and cannot be verified due to lack of measurements of these for many chemical species of interest.

The "state-of-the-art" air quality models can treat emissions from point sources and/or area sources, and can provide estimates of the quantitative distribution of concentrations, and wet and dry depositions in a given location, area or region. Specifically most of the existing models have been used to:

1. estimate contributions of given source to receptors
2. identify locations with maximum concentrations
3. estimate consequences of projected emission changes
4. fill the gap between observations
5. assist in field study planning, in determining which variable to measure, and in selecting monitoring sites
6. calculate amounts of pollution deposited by the precipitation falling to the earth's surface.

Existing models do not accurately simulate individual episodes. These vary as much as individual signatures. However, they presently provide a reasonably accurate picture of the average of a number of generally similar episodes, where the criteria of similarity are such things as vertical temperature structure of the atmosphere, winds, and types of precipitation. Since long-term effects on plants, soils, etc. tend to be cumulative, such time averaging is quite acceptable in the present study in relation to air quality modelling.

The most important aspect of the Alberta Study is the selection of a model for application during the project. This difficult task must be based on the specifications of the particular application under consideration at a given time. This committee believes that it is perhaps more appropriate to identify some aspects which the decision-makers may consider for selecting a model. These are:

1. Has the model been applied under comparable conditions and how did it perform?
2. Is the available data base suitable to drive the model?
3. Can the model provide information needed to determine ecological effects?
4. Are the temporal and spatial scales of the model germane to the acidic deposition estimates, and can it treat chemical species that have a role in the formation of acidic deposition?
5. Can the model be modified relatively easily for use in this specific study?

In addition to the dispersion models discussed in the preceding pages, mathematical receptor models have been used in North America to determine the origin of particles impacting a receptor site. All these models require source signature and ambient air quality data that include, generally, a large suite of elemental compositions ideally in the two particle size regimes (<2.5 μm and J2.5 μm).

How this works can be seen from a simplified example. Suppose that there are only two possible sources, both emitting SO_2 and particles. Suppose that particles from one source contain elements A and B in a ratio of 3:1, while those from the other have a ratio of 1:3. At the receptor (say, a field of barley) a high concentration of SO_2 is measured, and the associated particles are found to have a ratio of A to B of 1:1. If the assumptions made are correct and the measurements are exact, it is reasonable to conclude that the two sources contributed equally to the SO_2 concentration at the receptor.

In fact, measurements are never exact, there are never just two sources, and so receptor modelling is not so simple. Ratios of many elements are needed to unravel many sources. However, the concept is still the simple one set forth previously. The technique is powerful enough even to reveal sources not anticipated in advance. (Again to simplify, if the ratio of A to B in the aforementioned example were found to be 8:1 at the receptor, it would indicate that some other source high in A was contributing heavily to the pollution at that time.)

A complete examination, and uncertainties associated with the various types of receptor models, along with sampling and data required to complement source apportionment programs are contained in Appendices 2 and 3.

3.1.7 *Selection of Experimental Sites*

The major goal of this program is to investigate effects of emissions. The need is foreseen for two different kinds of air quality measurement sites, firstly those for more intensive (especially in time resolution) measurements at sites selected for studies of biological effects. Certain requirements concerning meteorology, terrain, and access apply in both cases. Other requirements, involving vegetation and ambient air quality, apply mainly to the case of the effects-related sites.

The mountainous terrain to the west causes some unique meteorological phenomena. Chinook winds cause locally extreme conditions that confuse the interpretation of biological effects data, while also ruling out the use of even complicated meteorological models for assessing dispersion and deposition. Orographic clouds can occur, with

possible influence on atmospheric conditions. Effects of this kind cannot be predicted with confidence, and hence it is recommended that potential research sites should be screened for possible meteorological irregularities using data obtained in preliminary exploratory studies conducted over a period of at least several months.

The selected focal areas should have existing access, sufficient for routine visits to all sites. Sites should be selected well away from areas likely to be developed during the period of the study, e.g. by construction of new roads, gas-producing facilities, etc.

Topography should be relatively simple, without surface features that might cause flow separation, shed vortices. The terrain need not be flat and featureless, but should not be complex. Gently rolling hills or sloping countryside would be acceptable. In the case of the sites identified for biological studies, the surface in the vicinity of the site should be sufficiently simple to ensure the applicability of micrometeorological multiple-resistance models for evaluating dry deposition fluxes (i.e. dose rates to exposed vegetation) of the important chemical trace gases and aerosols.

Moreover, interpretation of air quality and meteorological data requires a uniformity of surface vegetation that might not always be present. Care should be taken to avoid experimental locations in which vegetation cover is uneven, in either variety or state of growth. A perfect location is probably not obtainable in practice; however, efforts should be made to come as close as possible to the ideal of spatial homogeneity. Sites should be chosen to provide a uniform surface characteristic extending for at least several hundred metres around the focal area of biological effects work. Since dry deposition is affected by the character of the surface at which the plume impacts, land-use types in the experimental area should be characterized accurately.

The basic need to detect measurable effects imposes a bias towards conducting experiments in the vicinity of the largest sources, though this bias should be tempered by other considerations. Existing Gaussian plume dispersion models are adequate for predicting mean exposure conditions, especially within a few tens of kilometres of specific sources. Factors such as source strength and stack height can be taken into account. However, these models are best suited for the case of uniform terrain under stationary conditions. Application in the mountains terrain typical of western Alberta would not be advised.

Depending on stack height and prevailing meteorological conditions, maximum air concentrations of emitted species will often occur a few kilometres downwind from a source. The range of exposure conditions will be influenced by the likelihood of ventilation or direct plume impaction and by plume dilution under direct impaction conditions. While it is clear that study sites could be selected to provide a wide range of downwind exposure conditions, it cannot be assumed that test sites of sufficient surface similarity can be selected. Thus, it is possible that some careful preliminary and exploratory monitoring will be required to decide among alternative field sites in the vicinity of any selected emission source.

3.1.8. *Air Quality and Meteorological Measurements for Effects Sites*

Air quality and meteorological data should be monitored at every biological effects research site with detail sufficient to provide an approximate time record of dry deposition fluxes of the chemical species of major ecological importance (primarily SO_2, NO_x and O_3). These dry deposition fluxes constitute the time-varying uptake rates to vegetation, soils, and surface water that cause the consequence under investigation by the effects components of this program.

In the past, local air quality observations have often been used as the sole basis for relating observed effects to pollution. In reality, uptake rates are directly affected by meteorological and surface-related factors that vary over wide ranges. More sophisticated dose-response relationships now under development are starting to take these factors into account. For example, exposure to high concentrations of SO_2 at night when stomata are closed should not have the same effect on vegetation as might exposure in daytime when stomata are open. Likewise, local wind speed has a direct influence on the efficiency with which all air pollutants can be transferred to exposed surfaces. While many existing models fail to recognize such complexities, it is recommended that this program should anticipate the needs of models presently under development.

Table 3.1.4 lists air quality and meteorological data sampling considerations related to the need to evaluate surface fluxes as an intermediate step in dose/response studies. It is necessary that, during appropriate periods, measurements also must be made of a number of relevant biological factors, especially stomatal resistance and leaf area index, although not with the same temporal detail as for the air quality and meteorological data.

3.2 Vegetation Studies

3.2.1 *Agricultural Systems*

3.2.1.1 Current Status of Alberta Crop Production

The agricultural vegetation of Alberta is diverse and includes various crops, depending on latitude, topography, soil characteristics, and other factors. The highest priority need in the agricultural crop category is to identify whether there are, or could be, effects of acid-forming emissions, positive or negative, on the growth, quality and yield of this type of vegetation. The recommended plan for meeting this need includes the selection of a limited number of important crop species for detailed study at a limited number of sites. To facilitate this selection of species and sites, it will be essential to

assemble the following information on the current status of Alberta agricultural crop production:

1. Statistics on the major crop species of Alberta in their order of importance.
2. The most important and representative geographic regions, eco-regions, and soil productivity zones in Alberta.

Table 3.1.4

Requirements of coupled air quality and meteorological measurement at effect sites. Data are selected to provide inputs to drive a multi-layer, resistance-analogy dry deposition model of the kind discussed in recent dry deposition literature (e.g., Chapter VII of the U.S. Environmental Protection Agency. Critical Assessment Review Papers on Acid Precipitation).

a. Rapid-reponse, 1 minute time resolution

SO_2	Wind direction
NO_2	Temperature
O_3	Solar Radiation
Humidity	

b. Supporting Data

Stomatal resistance (as characterized in special case studies)
Leaf Area Index
Soil Moisture
Surface Water (e.g. snow, runoff, dewfall)
Precipitation
Particle dryfall

3.2.1.2 Crop Responses to the Environment

Detection of responses of crops to a particular stress, such as acid-forming emissions, require that crop responses to environmental factors and to other types of stresses be known well enough to minimize ambiguity of the causes of observed effects. Thus, it would be essential to obtain detailed information on:

1. Factors that influence productivity of Alberta crops.
2. Characteristics of plants exposed to known chemical, biological, and climatic stresses.
3. Trends in growth and yield of Alberta crops associated with changing management practices and alleviation of known stresses.

Plants are known to differ in sensitivity to stresses according to their genetic constitution and to the environmental conditions in which they are growing. Studies of effects of acid-forming emissions on plants necessitate that these sensitivity factors be known if cause-effect relationships are to be understood. Accordingly, it is *essential* that the relative sensitivity of agricultural species of concern be known. Information is needed on:

1. The genetic sensitivity of major Alberta crops and trees and the genetic sensitivity of cultivars and genetic lines actually used in commercial production. Uniformity of plants selected for study will be important as genetic variability decreases the sensitivity of experiments.
2. The environmental factors that alter plant sensitivity and the likelihood that such factors or combinations of factors will exist at particular Alberta locations.

As the sensitivity of most Alberta crops to SO_2 and NO_2 are not well known, it would be *desirable* to screen, in fully-controlled environmental gas exposure facilities, many of the important cultivars and genetic lines for sensitivity to these acid-forming gases.

Other plant factors may alter response patterns and increase the difficulty of interpreting cause-effect relationships. It would be desirable to have more information on:

1. The adaptive processes in plants of concern in response to relevant gaseous air pollutants.
2. Delayed or dampended responses to pollutants in these plants.
3. Recovery and compensatory growth responses in these plants.

3.2.1.3 Selection of Crop Species and Field Evaluation of Their Responses

When information on Alberta crops, their importance, and their sensitivity to stresses in the environment has been assembled and interpreted, it should be possible to designate prospective candidate species for intensive preliminary study leading to experimentation and effect evaluation at a selected site or sites. In order to answer the highest priority question regarding acid-forming gas effects it will be essential to undertake field experimentation and evaluation. Accordingly, the following approaches are proposed:

1. A series of sites to provide a gradient of pollutant doses should be selected in relation to one or more point sources within important ecological and economic regions. Such gradients will permit the estimation of dose/response relationships under outdoor conditions. At each site there would be two sets of plots of the most important species to permit the necessary growth, yield, and quality studies. At least one gradient would be chosen within an important cultivated agricultural area. This gradient approach to effects studies would be facilitated by locating at least one site upwind of the point source(s) and several sites downwind of the point source(s). Sites on two particular gradients would be chosen in part according to their ecological similarity. Ecologically-analogous sites will serve to minimize variability in site responses that might otherwise interfere with gradient response patterns.

2. On at least one site within a gradient of sites in a field crop production area, a set of open-top field exposure chambers should be constructed for studies of plant responses to known doses of acid-forming gases (SO_2 and NO_2) added to ambient air as simulated episodic occurrences. As dry deposition of gases is likely to have the greatest effect on plants, wet deposition and dry deposition of particulates will initially not be included in open-top chamber studies. Open-top field chambers are widely used in gaseous pollution effects studies, including the National Crop Loss Assessment Program (NCLAN) in the United States.

As ozone is known to be present in ambient Alberta air, this gas will be added to chamber air at stimulated ambient concentrations. Environmental conditions in such chambers are somewhat similar to open field conditions if properly managed, so results of season-long exposure regimes can be examined relative to plant responses in open gradient plots. It should be noted that such a site will require a substantial supply of electricity.

Treatment regimes (using O_3, SO_2 and NO_2) in the open-top chamber will be established in collaboration with air-monitoring specialists. It is suggested that a "worst-case" regime be devised by air quality specialists to mimic the highest possible combination of gases that might occur over the growing season at a particular site over a several-year period. This "worst-case" concentration might be experimentally exceeded to determine the threshold for significant effect.

3.2.1.4 Crop Response Evaluation

Crop growth and yield modelling provides a precise and thorough method for assessment of the relationship of plant responses to gas concentrations as modified by weather and other measurable factors (see Section 3.5 — Integration). Such an approach requires the collection of plant data from field plots on a regular basis. This approach will be feasible for field plots in the gradient approach but not in the relatively small open-top chamber experiments. For the latter, final yield and quality data should be obtained along with non-destructive growth measurements. It may be possible to incorporate valuable soil and moisture considerations into open-top chamber studies. Manipulation of plants should be vigorously avoided as permanent injury can occur. Instead remote sensing methods, such as photography, should be used. Experiments should be performed over several growing seasons to account for weather effects. For the crop modelling approach to be successful it is essential that the following kinds of data be available:

1. Detailed plant growth measurements on a frequent (e.g. weekly basis).
2. Comprehensive air monitoring data at the site for SO_2, NO_2 and O_3 and frequent monitoring of other possible perturbing components of the air mass.
3. Precise meteorological and soil data of the site.

3.2.1.5 Integration with Air Quality Activities

Close integration of the crop response evaluations with air quality measurements and modelling will provide the basis for realistic treatment regimes in open-top chambers. The following information is essential for this research.

1. The composition of ambient air and trends in its quality in Alberta.
2. The probability of the occurrence of concentration patterns leading to a prediction of the best regimes to use in the episodic, growing season exposure, including estimation or prediction of the "worst-case" scenario.
3. Predicted gradients from a point source to facilitate the placements of gradient plots in as quantitative a manner as possible consistent with ecological equality (i.e., similar soil, microclimate) of candidate plot sites.
4. A suitable $SO_2/NO_2/O_3$ combination for experimental exposure regimes, this combination to be based on actual air monitoring and emission calculations.
5. Ambient gaseous pollutant concentrations must be monitored continuously throughout the experiment at the same site(s) as the biological measurements.
6. Dry particulate and wet deposited inputs of chemical constituents; it is uncertain how these will be related to plant responses, as it is recognized that gaseous pollutants are the most reactive components on plants.

3.2.1.6 Other Essential Activities

Matters such as the extent of replication, statistical sensitivity of the experiments, and the differences needed for a meaningful response will require further discussion and elaboration. Supplementary observations beyond those required for response modelling should include visible injury symptoms and their severity, and quality and chemical composition of the final harvested agricultural commodity. Yield component analysis may provide important clues to crop response and appropriate measures of plant, inflorescence, fruit and seed number should be made. The cultural practices to be used at experimental sites will generally follow those of the most farmers in the area. It should be noted that the degree and intensity of agricultural management, including history of land use, may influence crop responses. Integration of plant responses with air, soil and water measurements will serve to identify management practices and climate effects that could interfere with a clear-cut assessment of pollutant

effects. As crop rotation schemes are followed by most field crop farmers, it will be important to consider the incorporation of such rotations in both the gradient plots and the open-top chambers over the several-year course of the experiments.

3.2.2 *Forest Ecosystems*

Forests of Alberta are utilized for a variety of purposes including recreation, timber production, watershed moisture stability, and wildlife habitat. The vast majority of productive forest land is managed by one government entity or another. Therefore, the stewardship of such lands is the responsibility of the public sector. No doubt the primary use of forest lands in Alberta is related to recreation, be it tourism, fishing, or hunting. The primary uses of forest land are not related to the production of marketable forest products requiring timber harvests. Natural regeneration of forests is the primary means by which forest tree population is sustained. In this context then, it is most appropriate to consider environmental influences on forests from the standpoint of essentially unmanaged systems as far as silviculture manipulation is concerned.

Research should be directed at understanding the mechanisms by which natural, relatively undisturbed ecosystems are impacted, beneficially and adversely, by components of the atmospheric and soil systems. Given a time constraint of five years within which research must be completed, it is not advisable that long-term ecosystem structure studies be pursued. However, the establishment of baseline data regarding species diversity, richness, and abundance might very well prove useful in future years and should not require an inordinate amount of financial support provided such information is collected primarily at sites established for other forest studies.

The most valuable information will be derived from research directed at understanding and monitoring processes and functions within forested systems. A thorough understanding of such processes not only has value in assessing the present health of a given system but can be used in models to predict the future complexion of Alberta forests. Such an approach can be successfully utilized within the time frame established for this effort.

To minimize the risk of not obtaining definitive results, either positive or negative, it is recommended that forest ecosystem studies can be pursued using a relatively sensitive plant community (sensitive to acid-forming materials as outlined previously) on a soil that permits readily observable response of forest vegetation to stresses, in a vicinity proximate to a substantial source of acid-forming emissions that may indeed represent a "worst-case" situation. Such soils are often inappropriately referred to as "sensitive" soils. By currently accepted terms of reference, soils sensitive to the effects of acid-forming materials are those that are easily changed in their physical, chemical, and microbiological characteristics by such stresses. Soils recommended for study in forest ecosystems may or may not be so categorized in order to meet the desired research objectives.

Inasmuch as large forest trees do not lend themselves to study via physical enclosures (or exclosures), it is suggested that a series of observation areas be identified in an upwind-downwind pollutant gradient system to identify direct stress influences on forest vegetation. In addition, controlled treatment studies in appropriate laboratory or greenhouse facilities are suggested to supplement field studies in an effort to elucidate stress influences on components of the ecosystem at a lower level of cellular organization and physiological activity. Certain processes in the ecosystem can only be studied in such a manner.

Stress factors that must be considered in the field include wet and dry atmospheric deposition, fluxes of gaseous pollutant concentrations, frequencies and durations of exposures, atmospheric and soil mixture, and other edaphic factors such as nutrient budgets and cycling soil hydrology, and microbial populations and activity. Microbial influences on plant productivity are of particular importance as they not only serve as indicators of changes in organic and inorganic constituent forms and amounts in soils, but are of paramount importance in the roles they play in organic matter decomposition, soil solution acidification, and subsequent mineralization of plant nutrients and toxicants.

Volumes of published research throughout the world demonstrate the importance of the mycorrhizal relationship on forest trees. Mycorrhizae function as "nutrient gathering" structures on plant roots and have a strong influence on the phosphorus nutrition of the host plant. Phosphorous is essential to the formation of energy-transferring compounds in plants. Mycorrhizae are also vulnerable to detrimental effects caused by several metals found commonly in soils, particularly manganese which has previously been implicated in air pollution effects related to sour gas processing operations and subsequent soil acidifications.

The effects of the multitude of growth-influencing factors acting in concert in forest stands are manifested in a variety of ways, some of which are height and radial growth of woody plant species, relative abundances of certain species, amounts of plant chemical constituents, and biomass. In addition to some of the obvious variables that might be quantified, total ecosystem biomass flux must include plant regeneration or reproduction, deposition of organic matter (litter), plant mortality, animal gazing, and vegetation harvested by man. A thorough examination of total biomass changes in an ecosystem is suggested to accurately ascertain the importance of anthropogenic atmospheric stresses.

Little attention has been given to influences of acid-forming materials on forbs occupying substantial land areas in forest ecosystems. Native grasses, in particular, serve as the major food base for many forms of wildlife indigenous to Alberta.

Concern has been expressed that increased trace element availability, resulting from increased soil acidity, could alter the nutritional characteristics of such plant species. It is conceivable that acid-forming emissions could not only alter nutritional quality within forb species, but also could cause changes in relative abundances of the same. Studies should be initiated to address such issues within the framework of ecosystem function and processes so that predictive uses can be made of the information generated.

Careful attention should be paid to related current and to previously conducted research in Alberta. There could be existing study locations worthy of consideration for additional or supplementary study which might provide information deemed necessary to meet some objectives of the research needs proposed in this document.

3.3 Soils Studies

The following criteria should be considered in selecting the sites for soils studies:

1. The sites should be of relatively high pollutant deposition input.
2. The sites include uniform and representative soils in Alberta.
3. The sites should include representative vegetation (crops) common in Alberta.
4. There should be a high probability of interactions between soil and the hydrological system.

3.3.1 *General Approach*

The general research approach should include the following objectives:

1. to characterize the pollutant deposition input (wet and dry).
2. To characterize the hydrology of the study sites.
3. To characterize the properties of the soils at the study sites.
   a. chemical properties
   b. physio-chemical properties
   c. microbiological and biochemical properties.
4. To attempt to detect changes in soils resulting from acid deposition.

The soils of the various study sites selected along the emission gradient will differ significantly in terms of their chemical and physical properties. It is important to obtain information on the effects of the deposition of acid-forming substances on soils in the study regions. Therefore, it is essential:

1. to exchange soil samples among sites selected along the emission gradient; and
2. that all the soil experiments be carried out with sufficient replications to minimize the variability expected in soil properties under field conditions.

3.3.2 *Specific Approach*

The specific approaches used will include studies of changes in soil and aquatic properties.

3.3.2.1 Soils Research

1. The soils of the sites selected should be characterized initially in terms of cation exchange capacity (CEC), exchangeable bases (EB), exchangeable acidity (Al^{3+} and H^+), organic and inorganic forms of each of C, N, S, and P, Al, Mn, free $CaCO_3$, and pH. The organic S form should be fractionated into C-O-S and C-S. The S and P fractions in the microbial biomass should be estimated, and the $\delta S^{34}S$ of the total S should be determined, because, when applicable, use of ^{34}S as a tracer should be an integral part of this research program. Sufficient numbers of soil profiles should be included from each site to allow for estimation of ion migration.
2. It is essential to characterize the soil solution. The analysis should include SO_4^{2-}, soluble and absorbed NO_3^-, Al, Mn, F, and dissolved organic C.
3. The fertilizer (N, P, and S) input in the agricultural sites should be closely monitored and the nutrient removal by crops should be determined.
4. The root biomass will be estimated in work carried out in the vegetation studies. It is essential to determine the nutrient content of plant roots, litter, and any crop residues remaining after crop harvest.
5. It is important to understand the effects of the deposition of acid-forming substances on the following microbial processes in soils:
   a. Nitrogen Fixation
      Symbiotic nitrogen fixation by higher plants provides a far greater input of N into most ecosystems than that from free-living organisms. Therefore, the effect of acid-forming substances on symbiotic N fixation in the study of the region should be evaluated. Also, the contribution of the N-fixation process to soil acidification should be considered.
   b. Nitrification
      The process ($NH_4^+ \rightarrow NO_3^-$) is mediated by a very few species of bacteria that are known to be sensitive to soil acidification. Since this process is an integral part of the nitrogen cycle, disruption of this process may affect the availability of nitrogen to plants and hence plant growth.

c. Denitrification
The process ($NO_3^- \rightarrow N_2O \rightarrow N_2$) involves important reactions of the N cycle that affect the available nitrogen and soil pH. Therefore, it is important to study the effect of acid deposition on this process.

d. Sulphur Oxidation
The process ($S^0 \rightarrow SO_4^{2-}$) is an integral part of the sulphur cycle in soils. Addition of reduced forms of S to soils as a result of acid deposition will result in an amplification of this process.

e. Sulphate Reduction
The process ($SO_4^{2-} \rightarrow S$) is also an integral part of the sulphur cycle in soils. Disruption of this process could lead to an increase in the SO_4^{2-} concentration in soil and an increase in soil activity.

f. Carbon Dioxide Evolution
This process ($C \rightarrow CO_2$)is an index of the activity of heterotrophic microbial population in soils. It may be a sensitive indicator of deposition of acidifying substances to soils. If the rate of carbon dioxide in soil is reduced as a result of acid deposition, the rate of mineralization of organically-combined soil materials could also be reduced. In addition, acidification of surface soils may lead to reduction in the rates of decomposition of litter in forested soils and crop residue in managed soils.

The analytical methods and other procedures needed for the work proposed for soils research are described in Monograph No. 9, Part 2, of the American Society of Agronomy on Methods of Soil Analysis edited by A.L. Page et al. (1982).

3.4 Aquatic Studies

3.4.1 *General Approach*

Acidification of surface or groundwaters entails a reduction in alkalinity (acid-neutralizing capacity) which may in turn result in decreased ph and increased levels of potentially toxic metals. These latter changes are the primary factors associated with stress to aquatic biota. Accordingly, the major questions which must be addressed initially to establish a quantitative link between atmospheric acid deposition and aquatic ecosystem acidification are as follows:

1. Determine current acid/base status of aquatic receptors and assess potential sensitivity.
2. Are there existing gradients in surface or groundwater alkalinity along atmospheric S deposition gradients (in potentially sensitive areas).
3. If alkalinity gradients are evident, establish the contribution of atmospheric acid deposition by analysis of relative acid/base supply rates along the gradient.
4. If alkalinity gradients are not evident, determine the compensatory processes responsible for acid assimilation and the capacity of the system to withstand continued or increased acid loading.

Potential biotic responses to acidification stress include alterations in ecosystem structure and function. However, dose-response functions and models which incorporate these responses are not currently available. Description and documentation of these perturbations in critically acidified systems should be undertaken with these limitations in mind.

3.4.2 *Specific Approach*

System alkalinity or acidity is determined by the relative acid and base supply rates from both external and internal sources. Quantification of these rates provides an approach for assessing the effects of changes in external acid supply rate (e.g., atmospheric deposition) and a means for evaluating the relative importance of internal system processes that consume or produce acid. Models of the acidification process in aquatic systems (e.g., Integrated Lake — Watershed Acidification Study, ILWAS) could provide a framework for the organization and evaluation of this analytical approach. The input parameters, system characteristics, and processes that should be quantified are listed below:

1. Total deposition of major ions and total sulphur input.
2. Hydrologic budget. Should include evaluation of relative contributions of direct precipitation, surface interflow, and groundwater to the annual hydrologic budget of the system. (Flow paths and residence time of water in specific soil horizons may significantly determine alkalinity or acidity supply.) This may entail direct flow measurements and/or the use of elemental isotopic ratios for estimating relative contributions.
3. Physical system parameters (e.g., soil depths, permeabilities, vegetative cover, lake or pond morphometry).
4. Thermal stratification and mixing regimes.
5. Rates of alkalinity of acidity production from terrestrial soils (identify key processes).
6. Compensatory significance of internal SO_4 reduction and denitrification during anoxia as an alkalinity source (stratified ponds or lakes).

3.4.3 *Site Selection Criteria*

Potentially sensitive aquatic receptors will be those receiving a major portion of their water input from either direct precipitation or shallow and rapid interflow through organic or sandy soils. Kettle ponds with basins perched above the water table represent the most sensitive type of aquatic receptor. On a temporal basis, small streams and shallow drainage lakes or ponds situated in sandy or organic soils might also exhibit sensitivity to atmospheric acid deposition during peak flow periods.

Sampling and analytical methods should conform to protocol specified for water chemistry and biological surveys by the U.S. Environmental Protection Agency (EPA).

3.5 Research Integration

On the basis of much research experience around the world over the last ten years, it is evident that there are several different levels of integration possible for a research program. In the most elementary sense, any program that has a variety of research tasks addressing conditions in the atmosphere, vegetation, soils, and water does possess some primitive potential integration. However, that level is so vague and nominal as to be far less than optimally useful for coordinating and planning the research to assure that it directly and efficiently contributes to the desired overall purposes and objectives for establishing the research program in the first place.

When research scientists representing various specialties initially meet together to begin a research program, they identify how they think various processes in the landscape ecosystem are connected and how they interact. However, in some research programs the low level of integration with which they allow themselves to be content often ends up to be only a general box-and-arrow flow diagram and a verbal description of the ecosystem relevant to the environmental problem. This level of integration, which might be called *conceptual integration*, is fine as a first step, especially for serving as a focal point for all persons involved in the research program to use as a frame of reference for communications and some elementary planning. The disadvantage is that this level of integration does not go far enough for identifying and justifying the specific research topics that are absolutely essential for achieving the new information needed to resolve the environmental problem. Nor does it provide the tools needed to assess the current environmental situation or to predict the likely consequences of possible alternative future conditions in the environment.

The next level of integration of a research effort might be called the *analytical* level. It occurs when each of the research tasks focused on various environmental processes (changes in energy or matter in the ecosystem) are sought to be quantified as sets of mathematical statements. For example, some particular vegetation characteristic may be intentionally researched to establish its quantitative relationship to meteorological and/or soil properties. Unfortunately, some past environmental programs have demonstrated this degree of integration on a catch-as-catch-can basis largely as a result of the personal interests of some of the scientists involved in the program and not as a part of an initial and directed overall research plan for the whole program. While this level of integration is a step above the previous types of integration mentioned, the fact remains that this level is still largely accidental throughout the program and does not lead to the overt use of a holistic conceptual framework for use of researchers, project managers and concerned public-interest groups.

The next higher level of research program integration, which might be called *synthetic*, consists of the concerted plan at the outset of the program to develop and use one or more coordinated and well-connected mathematical models of various processes in the environmental system as a whole. Ideas on how the processes work, based on the current state of scientific knowledge, are described as sets of mathematical relationships which are interrelated to each other, in contrast with the former level of integration which is more piece-meal. The system model assembled and used at this level of integration is implemented on a computer and the behavior of this computer model, which attempts to mimic environmental changes over time, is compared with similar actual measurements made out in the landscape at field research sites. The purpose of this is to see how well, or how poorly, the model behaves when compared with the real-world ecosystem. There are many published examples of agricultural and wildland (forest, grassland, tundra) ecosystem models that have been developed for non-pollution situations, although some of them could be modified and improved to be usable for various kinds of pollution solutions. This level of integration at least produces one or more potentially predictive tools that can be used by environmental risk assessment personnel. It does fall short of the maximum level of research integration, however, because in programs where these computerized environmental system simulators have been researched and developed, often there was little time left at the end of the program life cycle to actually make use of the field-tested models to conduct computer simulation experiments. This latter activity is the next level of research and information integration.

At this level, which might be called the *systems simulation* level, program analysts use the developed ecosystem process model to perform computer simulations to forecast what might happen if various alternative and possible future conditions occur. For example, what might happen to particular forms of vegetation growth in the landscape if the gaseous emissions over the next twenty years are reduced by 50 percent, or remain very much as they are at present, or alternatively, increase by 100 or 200 percent?

It should be recognized from this description that the increasing levels of integration provide a

more and more tightly focused, highly coordinated, and cost efficient research program. Experience in many research efforts, however, has shown that increasingly higher levels of integration are only possible if well-planned immediately at the outset of the program within the very basic program design. Integration is not something that can be achieved later in the lifetime of the research program if it was not designed into the program at the beginning. There is much evidence from previous North American research programs that setting up field data collection designs and natural resource surveys without first having applied environmental systems analysis techniques to obtain relevant, explicit models, leads to subsequent fragmentation of research and no possibility for a high level of integrating any resulting new information.

Discovering whether there are, or can be, ecological effects of dry and wet acid deposition from the atmosphere over Alberta's ecoregions under a variety of land management practices requires consideration of a very complex system. We recommend that ecological *systems analysis* and *computer simulation* modelling under the levels of integration called *synthetic* and *systems simulation* can be used as the approach to integrate the relevant needed research toward meeting the project objectives and providing a holistic view of what is happening in Alberta's landscapes.

One of the first activities that needs to be conducted as soon as possible for further designing, coordinating, and integrating the specific research in this program should be evaluation of existing mathematical ecological computer simulation models for atmospheric deposition, vegetation, soils, and water. This must be done as soon as possible to establish the framework for a strongly integrated program.

In addition, it is essential that, as soon as possible (over a few weeks), a critical review of potential usefulness and limitations of the existing published, mathematical computer simulation process models of agronomic, horticultural, and forest stand (crop) growth be made.

The usefulness and limitations should point out which are the models that should be used as a starting point for identifying and organizing the additional needed research information as it pertains to the present research program. This effort will help in obtaining a vegetation response model that includes foliar and root uptake, translocation, bioaccumulation in plant organs, and growth and harvestable-yield changes possible as a consequence of exposure to dry and wet deposition of chemical substances from industrial point sources.

Such additional needed information should emphasize the data and measurements needed on soil conditions (for subterrestrial exposures) and statistical and temporal characteristics of atmospheric deposition (for above-ground, aerial exposures). Particular attention should be directed to sulphur-cycling. These information needs should be presented as required monitoring for soils and atmospheric scientists.

Statement of Verification

We the following, upon the invitation of the Biophysical Technical Research Committee of the Alberta Government Industry Acid Deposition Program, participated in a workshop held in Calgary, Alberta (12-16 September, 1983). The attached document is a *DRAFT* research plan which we believe will satisfy the defined objectives of the program.

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List of Appendices

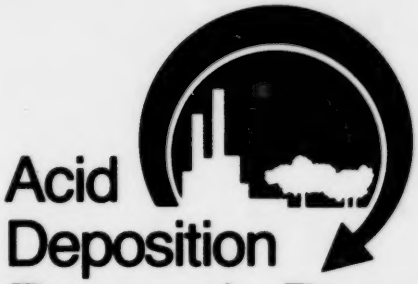
APPENDIX 1. AIR QUALITY AND DEPOSITION MODELS

Bhumralkar, C.M. and R.E. Ruff. THE ACIDIC DEPOSITION PHENOMENON AND ITS EFFECTS. Critical Assessment Review Papers, Vol. 1, Chapter 9. U.S. Environmental Protection Agency, Office of Research and Development, Washington, D.C. EPA-600/8-83-016A (draft)

APPENDIX 2. FUNDAMENTALS OF RECEPTOR MODELING

Henry, Ronald C., et. al. REVIEW OF RECEPTOR MODELING FUNDAMENTALS: A REPORT FROM THE MATHEMATICAL AND EMPIRICAL RECEPTOR MODELS WORKSHOP (Quail Roost II).

APPENDIX 3. Gordon, Glen E., et. al. CONSIDERATIONS FOR THE DESIGN OF SOURCE APPORTIONATE STUDIES: A REPORT FROM THE MATHEMATICAL AND EMPIRICAL RECEPTOR MODELS WORKSHOP (Quail Roost II).



HUMAN HEALTH WORKSHOP

January 1984

Executive Summary

This document is a report on the outcome of a government/industry sponsored workshop held to discuss the potential human health effects of acid-forming emissions emanating from Alberta industries. Twenty-three eminent North American scientists, representing over seventeen areas of expertise, met in Banff to assist the Human Health Committee in developing a comprehensive research required to resolve key environmental and health questions pertaining to acid-forming emissions.

The experts' recommendations at the Acid Deposition Research Program (ADRP) Human Health Workshop are based on two premises:

1. that the potential impact of acid deposition on the health of Albertans requires urgent and concerted action.
2. that public complaints of health problems are a valid starting point.

After a thorough and complete review of available documentation the scientists concluded that the research completed so far in the Province does not provide the necessary information on which to base concrete research proposals. A comprehensive medical diagnostic review was recommended to be undertaken to determine the nature of long-standing health complaints.

The experts also recommended the following:

1. **Epidemiology Studies based on:**
   a) community epidemiology using cross-sectional studies followed by prospective studies;
   b) occupational epidemiology of both high and moderate exposures;
   c) exposure monitoring using environmental monitoring at sites selected by epidemiologists; human biological monitoring and screening; and methods assessment.

2. **Clinical Service and Field Research Programs through four approaches:**
   a) A community input program using a toll-free 'hotline'.
   b) A central repository of environmental and health effects data.
   c) An environmental health medical referral unit such as a tertiary referral centre attached to a university hospital.
   d) A field investigation team to immediately follow-up emergency or unusual pollution episodes.

3. **Human Clinical Research and Animal Toxicology:** to provide new knowledge on the toxicity of unstudied compounds or mixtures of compounds.

4. **Behavioral-Environmental Health Issues:** The valid information base required for informed decision-making should be developed through four mechanisms:
   a) Surveying individual perceptions.
   b) Investigating the influences of odour in reporting symptoms.
   c) A historical study of factors leading to community conflict.
   d) Periodic sampling of residents in affected and non-affected regions.

The experts identified three organizational components which are necessary to preserve and enhance Government and Industry credibility:

1. External scientific control of the program through Scientific Advisory Body (SAB).
2. A referral system for study participants who may have undiscovered illnesses.
3. Community liaison through public representatives who are fully accredited members of all standing committees connected with ADRP.

These recommendations provide not only specific research projects to be conducted within ADRP over the next six years but also a blueprint for a general approach that can be used in resolving other environmental health problems associated with the development of Alberta's natural resources.

1. Introduction

The potential adverse impact of acid-forming emissions on the environment is one of the most significant environmental problems to be encountered in North America in the last two decades. Apart from proven effects on the environment, considerable controversy and fear still surround the potential effects these emissions may have on the health of humans and animals, either directly through absorption and inhalation of the emissions or indirectly through ingestion of contaminated food and water.

In Alberta, the development of sulphur-containing natural resources results in the release of acid-forming emissions (e.g., SO_x, NO_x, H_2S) and other associated compounds (e.g., metal particulates, organics). The concern that these emissions may affect the health of Alberta citizens has been the topic of considerable discussion over the last twenty years, particularly in relation to the development of the sour gas industry. Numerous studies and public hearings have been conducted and several reports with attendant recommendations exist to try to resolve this issue. Yet, the fact remains that it is still unclear whether a direct cause-effect relationship exists between exposure to these emissions and reported health complaints and what role, if any, numerous confounding variables such as lifestyle may play in the issue.

In response to the continuing ambiguity surrounding this issue and the continuing concern and efforts of many individuals within Government, industry and the public sectors, the Alberta Government and a consortium of industries created jointly the Acid Deposition Research Program (ADRP) to:

- develop a comprehensive understanding of the effects of acid-forming emissions on the

environment.
- provide a sound scientific basis for the long-term management and regulatory control of these emissions.

In order to achieve these objectives it was recognized that high quality research was essential in both the biophysical and human health areas. Furthermore, it was recognized that this research should be integrated as much as possible to provide more complete answers to key environmental questions. To this end the Members Committee of ADRP established two technical sub-committees to develop appropriate research strategies in the human health and biophysical areas.

The Biophysical Technical Research Committee held a workshop in September 1983, the report and recommendations of which have been submitted to the Members Committee.

The Human Health Workshop was organized and conducted in Banff, Alberta January 22 - 27, 1984. The remainder of this document is the report of the Human Health Committee on the outcome of that workshop.

2. Human Health Committee Terms of Reference

The Human Health Committee, after reviewing the 1979 terms of reference of the Alberta Petroleum Industry Governmental Environmental Committee (APIGEC) and the terms of reference provided by the Executive Committee (ADRP), adopted the following terms of reference:

"To assist in the planning of an integrated research program on acid-forming emissions by:
- identifying major issues relevant to short and/or long-term effects of acid-forming emissions on humans.
- defining a comprehensive research strategy that can be used to quantitatively or qualitatively assess the effects of acid-forming emissions on human health.
- integrating in a holistic manner the human research strategy with essential biophysical strategies to assess or predict the impact of acid-forming emissions on human health."

The Human Health Committee recognized that the Acid Deposition Research Program faced both monetary ($8 million) and time constraints (7 years) in meeting its mandate. This, therefore, necessitated a more precise definition of the scope of potential human research projects to be conducted with ADRP. The Committee felt strongly that:
- attention should be restricted to human health issues within Alberta. The human research program should, however, be cognizant of other provincial, federal and international research efforts in this area to avoid unnecessary duplication of research efforts as well as to enhance the interchange of relevant research findings.
- research projects should be resricted to human studies (e.g., clinical, epidemiological). Wild or domestic animal studies should not be initiated within ADRP to complement these studies. However, the human research program should be cognizant of animal research findings generated by other Alberta institutions or abroad that could be used in clarifying or testing correlations between exposure to acid-forming emissions and observed or potential human disease conditions.

3. Human Health Workshop: Approach and Planning

Given the mandate of developing a research strategy in the human health area that could be integrated with essential biophysical strategies to assess or predict the impact of acid-forming emissions on humans, the Human Health Committee commenced its planning with a review of both the past and present health situation in Alberta. It was concluded that although numerous attempts had been made to address environmental health concerns, most fell short of being either scientifically or publicly acceptable. It was felt that one of the principle reasons for this was the focus of many studies on the measurement and characterization of acid-forming emissions from various point sources and the interpretation of the potential human health effects of this information by non-medical professionals. Other reasons include:
- too narrow an approach to a multi-faceted problem
- inadequately designed studies
- the perceived lack of commitment and understanding by government or industry in resolving real or perceived environmental health problems
- the lack of credibility attached to many government or industry studies
- the lack of input by appropriately trained health scientists and medical professionals in the approval and design of health studies
- the lack of involvement of the public in the initial stages of health studies
- the lack of direction and coordination by government and industry in this area
- inappropriate interpretation of study results to demonstrate casual relationships

In view of the overwhelming complexity of this health issue, the Committee concluded that a multidisciplinary approach was mandatory for the development of a comprehensive human strategy. The decision was made, therefore, to seek the input of experts to cover the range from basic sciences to the health of populations. These included:

- respiratory
- gastroenterology
- neurology
- behavioral (sociology/ demography)
- reproduction
- mutagenesis
- nutrition
- cancer
- dermatology
- cardiology
- metabolism/ endocrinology
- epidemiology
- ophthalmology

- teratology
- biostatistics
- nephrology
- analytical chemistry (atmospheric & biological metals)
- immunology
- congenital effects
- susceptible populations

It was recognized that, in addition to the above, many experts would bring a knowledge of other areas as well. Moreover, it was recognized that many basic scientists or clinicians could be chosen for each of the above areas of expertise. However, since toxicologists generally play a lead role in interpreting the biological significance of such data, it was decided that the advisors should have a sound knowledge of the effects of various toxicants within their specialty area as well as an understanding of toxicologic principles. In addition, it was felt that there should be a balance between clinical and research-oriented specialists and that the experts should be currently active in a research or clinical setting. It was believed that these criteria would enhance the chances of developing a comprehensive research strategy, would maximize the applicability of research results to the Alberta situation, would avoid unnecessary duplication of research effort and keep the number of experts within reasonable limits.

Other criteria used in the selection of expert advisors were as follows:

- eminence in the area of interest
  - internationally renowned scientists as advisors
  - experience in the human health effects of air pollutants
- availability
- external to Alberta
  - avoid potential conflicts of interest (e.g., advisor also potential researcher)
  - provide fresh, external, objective opinions
  - increase credibility with the public

The credibility issue was of considerable concern to the Committee. It was felt that the situation within Alberta at the present time was one of confusion in both the public and scientific sectors over the validity of research findings. This appears, in large part, to be the result of the conductance of studies that by normal scientific standards would be rejected at an early stage. While it was recognized by the Committee that the attainment of both scientific and public credibility would be the ideal outcome of the Human Health Workshop, it was also recognized that factors such as time and freedom for exchange of scientific ideas and opinions imposed certain constraints on the format of the workshop that would detract from the ideal. Consequently, three decisions were made:

1. to conduct private sessions
2. to restrict attendance of these sessions to experts, organizers and key resource individuals
3. to ensure that the concerns of the major stakeholders in this issue (i.e., government, industry, public) were presented to the experts in a fair, open and unbiased manner through an initial briefing.

With regard to the first and second points only those individuals in Appendix 2 attended the sessions held between Monday morning (January 23, 1984) and Thursday evening (January 26, 1984). Members of the Members Committee (ADRP) and designated "observers" were present during the summary session on Friday, January 27. The general feeling of the expert group was that this was both appreciated and necessary in order to accomplish the task in the allotted time.

With regard to the third point, the Committee gathered together and reviewed all available documents central to the theme of the workshop. An information package was sent to each expert for review prior to their attendance at the workshop (see Appendix 3). Where feasible, complete documents were sent. Otherwise, copies of the executive summaries and/or recommendations were provided. Complete copies of all reports were made available during the workshop. In addition to this, several related references were made available to the experts (see Appendix 3).

Public concerns were presented to the experts in the following ways:

- video reference material presented during the workshop
- public reports (e.g., Environment Council of Alberta (ECA); Lodgepole Inquiry submissions)
- comments from Dr. M. Kostuch and Dr. R. Shaw (representing environmental concern groups) in the opening session on Sunday evening (January 22)
- comments from Mr. Vern Millard (Chairman, Energy Resources Conservation Board) reflecting the types of concerns being transmitted through their public hearing process.

Lists of provided materials appear in Appendix 3.

The intent of the Human Health Committee was to get the experts "up to speed" as quickly as possible and provide a broad overview of the Alberta situation. To facilitate this process specific "resource" individuals were present to answer technical questions during the workshop.

It is important to note that while resource individuals were permitted to contribute to some of the private sessions, they were not permitted to vote on any final recommendations. This was also true for members of the Human Health Committee. The Committee felt this rule was essential in order to preserve the independent and unbiased process by which the expert recommendations were generated.

Perhaps the most important facet of the approach to the Human Health Workshop related to the specific questions that were posed to the expert advisors. Given that the present situation in Alberta is such that the nature and magnitude of real health problems is not known, it was decided that the most important question was:

"Based on your knowledge and the information presented to you regarding the Alberta situation, *IS*

there a health problem caused by exposure to acid forming emissions in Alberta?"

The Human Health Committee concluded that the distinction between an "Is there . . ." question and a "Could there be . . ." question would have a significant impact on the type of research strategy developed by the experts.

IS THERE? In this instance, there is no doubt from a public perspective, that a health problem exists in Alberta. But, from the perspective of health research alone, it is still unclear whether a specific diagnosed health problem exists. Posing this question, therefore, not only allowed the knowledge and experience of the experts to enter into the answer but also assisted in identifying the specific kinds of research needed to answer the question. This, in turn, should provide a clear decision point respecting the necessity of future human health research with ADRP.

COULD THERE BE? Posing this question, on the other hand, was not considered legitimate since the answer to this question would most certainly be "yes, there could be." It was felt that this approach could easily become self-serving and create a "research for research sake" program. The Committee feels that this is not a valid or cost-effective method of addressing complex environmental health questions within applied research programs that have fixed budgets and longevity (e.g., ADRP). More specifically, this kind of approach increases the likelihood of testing the wrong research hypotheses.

4. Expert Advisors Report and Recommendations

The following eleven (11) pages represent the complete report and recommendations of the expert advisors who participated in the workshop. This document has in no way been altered by the Human Health Committee. A statement of verification of its authenticity by twelve of the invited experts appears on page 34. The remaining eleven participating scientists have reviewed the document following the workshop and have transmitted their verbal and/or written approvals to the Committee.

Introduction

The potential impact of airborn industrial pollution on the health of Albertans requires urgent and concerted action in order to define the nature and magnitude of the problem and identify solutions. For example, while data are inadequate at this time for even a preliminary understanding of cause-effect relationships, it is nonetheless apparent that exposure to the emissions of sour gas plants and related installations can have a detrimental effect on human health. On one end of the continuum are acute effects on small numbers of individuals, e.g., gas field workers "knocked down" or killed by short-term high concentrations of H_2S. At the other end are the large numbers of complaints and symptoms which are attributed to chronic exposure to the emissions from sour gas processing plants. The research program proposed here is prompted by this situation and is based on the premise that complaints of health problems from members of the public are a valid starting point. Adequate and appropriate studies have not yet been performed to determine the magnitude or nature of the health problems.

Workshop members had difficulty defining the nature of the chronic complaints of residents in affected communities, in part because of evaluations to date. Because of the potential consequences of exposure, we therefore recommend that residents with long-standing complaints which they ascribe to the emissions of sour gas plants be offered a comprehensive medical diagnostic review to determine the nature of their illnesses. This should be accomplished at the earliest possible time, even prior to the initiation of proposed research studies.

Approach

The proposals given below represent several approaches to determining the nature and extent of potential health hazards associated with industrial air pollution in Alberta. These proposals were prepared at the request of the Members Committee of the Acid Deposition Research Program, which is ultimately responsible for adopting a course of action.

The Workshop recommends the following:

I. initiation of both community-based and occupationally-based epidemiological studies
II. establishment of clinical service and field research programs
III. initiation of a coordinated human clinical research and animal toxicology program
IV. establishment of studies to deal with behavioral-environmental health issues.

In addition to the specific approaches, we further recommend the following:

a) creation of a mechanism to ensure co-ordination of the above program
b) external peer review mechanisms.

I. Epidemiological Studies

Rationale: Epidemiological investigations provide direct evidence of adverse health effects in populations. Three distinct approaches are recommended: community studies, occupational studies and exposure monitoring.

a) Community Epidemiology

Cross-Sectional Study

To carry out cross-sectional surveys, exposed and control communities would be selected on the basis of emissions data, atmospheric models and monitoring data provided by the Biophysical section of the Acid Deposition

Research Program. Community selection should be stratified geographically, e.g., from urban, foothills and prairie areas. Matching of exposed and control communities on resident characteristics including age, sex and social-economic status is also important.

Health outcomes to be measured would include dermatological, ocular, neurological, psychological, pulmonary and cardiovascular signs and symptoms. Testing using hair, nail and blood samples should be used to measure exposure to elemental pollutants. Enzyme assays for nutritional deficiencies and potential toxic effects should also be conducted.

Prospective Study

Having identified the possible health outcomes of exposure to industrial pollution through a cross-sectional approach, a prospective study of individuals in selected communities should be undertaken to increase understanding of casual relationships. Both chronic and acute intermittent exposure, for example, to flaring, would be studied. Such techniques as surveillance diaries and telephone contacts would be added to the methods employed for the cross-sectional studies.

b) *Occupational Epidemiology*

Estimates from industrial and government sources suggest that as many as 100 workers per year in the gas and oil industry can suffer from "knock-downs". These are episodes of unconsciousness related to exposure to high levels of sour gas; the number of workers potentially at risk is substantial. Workers in this industry should be studied to investigate both the acute and chronic effects to both moderate and high levels of exposure. Findings from these investigations would be used to identify health effects to be addressed in the community at large.

Cohorts of workers should be identified in sour-gas, sweet-gas and thermal gas. These workers would receive standardized medical examinations focusing on respiratory, neurological, dermatological and ocular systems. Monitoring of exposure to H_2S and other compounds should be done at the plant and in some cases using personal dosimeters. Cross-sectional and longitudinal comparisons between workers in different cohorts should be performed to evaluate health effects. Cases of acute high exposure should be compared with matched controls.

c) *Exposure Monitoring*

Environment Monitoring

With regard to community epidemiology, continuous environmental monitoring should be carried out in the study areas. This should be sufficiently extensive to allow categorization of the degree of exposure of the residents in the area and to allow identification of sudden increases in exposure throughout the study period. Indoor-outdoor monitoring studies should also be carried out in a subsample of households in the study area.

Human Biological Monitoring and Screening

Measurements of the body burden of certain elements should be carried out; these would include Cu in whole blood, and other elements in body fluids or tissues (hair and nail), as well as through enzymatic analysis (such as GPX and SOD). Should deficiencies or toxic levels of any of these elements be found, multi-element monitoring of body intake should be conducted.

Methods Assessment

The reliability of all analytical methods used for monitoring purposes should be thoroughly evaluated. Qualitative measurements, followed by quantitative analyses where required, of major emission sources should be done to look for possible chemical constituents which have not yet been identified and which could adversely affect health status. Consideration should be given to the development of a low-cost personal badge-type dosimeter for H_2S based on metal salt-impregnated tape or similar material. If these already exist, they should be evaluated. The badges would be used in sour gas plant operations to obtain *semi-quantitative* data on H_2S exposure in the same way film badges are used in the nuclear industry. Using estimates of individual H_2S exposure and knowledge of raw gas composition, methods for making exposure estimates to CS_2, mercaptans and other compounds should be developed.

II. Clinical Service and Field Research Programs

In order to address additional needs in the area of environmental health, the Workshop makes the following recommendations:

a) *Community Input Program*

Establish a community input program by setting up a toll-free environmental "hot line" to register complaints and symptoms on a 24 hour a day basis. This will create

an inventory of, and allow a correlation of, symptoms with environmental monitoring data. The caller will be asked for symptoms, location and other basic information according to a standardized questionnaire. It is understood that such a toll free telephone line will include a feed-back system, i.e., a mailed response to the caller. Information from these calls will be computerized and will be used to identify patterns of symptoms and complaints.

b) *Repository*
Establish a repository of selected environmental, monitoring and health effects data using existing sources, e.g., field monitoring, stack emissions, plant air quality and phone-in information.

c) *Environmental Health Medical Referral Unit*

Establish a Medical Report Unit within a university hospital. This Unit will serve as a tertiary referral centre for medical diagnostic evaluation and care. It will be staffed by hospital personnel and will act as a continuing education centre to the community through local physicians and interact with industry as well. The Unit's activities would be closely integrated with the environmental information acquired by the call-in and monitoring programs.

d) *Field Investigation Team*

Establish a field investigative team in order to meet special requirements of the community during periods of unusual pollution episodes and/or clusters of symptoms and complaints. This multidisciplinary team would be sent out to the community and would have the capability to evaluate the health of the residents as well as to determine whether analytical and toxicological studies should be undertaken.

III. Human Clinical Research and Animal Toxicology

The large quantity of health and monitoring data derived from both the epidemiological and surveillance studies will necessitate the establishment of toxicological research programs both at the human and animal level. Acute, subchronic and chronic toxicological effects of different pollutants, alone and in combination, should be investigated. Studies are needed that would simulate the levels of unusual and accidental exposures. The importance of close ties between the basic and applied research programs and the human health studies cannot be emphasized too strongly.

There is presently a relatively large body of toxicological information available on the potential health effects of some of the pollutants of concern such as SO_2 and heavy metals. There is less information available on other compounds present in the emissions such as H_2S, carbon disulfide and mercaptans. Additional information is needed on the chemical and physical composition of fugitive, flare and stack emissions. This information can then be used to identify gaps in existing knowledge on the toxicological effects of compounds present. The case studies on the affected population will also provide useful input into planning specific studies with mixtures of emissions to determine if synergism and/or antagonism occurs. The studies should range from short term to longer term exposures in the appropriate test system.

IV. Behavioral-Environmental Health Issues

Public opinion about environmental health questions is a crucial aspect of exposure to industrial emissions in Alberta. However, lack of valid and reliable data base on perceptions and behavior of community residents restricts the ability of government planners and industry representatives to meet local needs. To provide adequate channels of communication, to establish a system for periodic assessment of local opinions, and to examine the impact of the mass media on environmental health issues, we recommend the following:

a) Surveying individuals' perceptions of emissions and of atmospheric pollutants should be undertaken in potentially exposed and control areas. Residents should be examined as to behavioral changes, alterations in daily activities and self-health perceptions related to the presence of industrial emissions. The perceived level of emissions should be compared with station monitoring data where these are available.

b) An investigation of the influence of odour in the reporting of symptoms should be undertaken. Environmental pollutants vary qualitatively and quantitatively in the composition of the gases and intensity of odour. It is likely that individual residents vary in their sensitivity to odour. Variations in perceptions of odour and its effect on the reporting of symptoms should be studied.

c) The examination of factors leading to prolonged conflict within communities about environmental health problems may provide information for reduction or prevention of future conflicts. Therefore, a history of the sour gas problem at Pincher Creek should be compiled.

d) That air quality is of great concern is evident from opinion polls about health and environment issues. It is expected that opinions will be affected by the occurence of mishaps in a plant or drillsite or by improvements in the quality of air in Alberta. Periodic sampling of residents in affected and non-affected regions will be undertaken. This will permit periodic surveying of perceptions of emissions by

residents, examination of sub-group variation with measures of change over time.

Organizational Principles

1. *Scientific Control of the Program*

The member committee of the Acid Deposition Research Program (ADRP) should select independent, internationally-recognized scientists representing atmospheric and analytical chemistry, epidemiology, toxicology, behavioral sciences, statistics and clinical research to serve as a Scientific Advisory Body (SAB).

The purpose of the SAB would be to draft specific requests for proposals (RFP) that would be the basis for the initial activity of the Program. These RFP's should be advertised nationally and proposals should be reviewed and ranked by a peer review body appointed by the SAB. The final recommendations for funding should be made by SAB, taking into consideration relevance, priority and funding levels.

The SAB, in collaboration with the Members' Committee (ADRP) should develop a mechanism to ensure the coordination of the activities discussed in this document.

2. *Referral System*

For any studies involving the evaluation of community residents, it is likely that previous undetected disease that may or may not be related to environmental exposures will be found. As part of any proposed investigation, one component must be a plan for providing appropriate referral of study participants. This may be to local medical resources or to a tertiary medical facility, depending upon the nature of the study.

3. *Community Liaison*

Representatives drawn from the public should be fully credited members of all standing committees connected with the Acid Deposition Research Program.

Peer-reviewed medical, scientific and other information relating to industrial emissions should be communicated to the public by the mass media and to specialized audiences. The dissemination of accurate information through print or broadcast media is especially useful in containing the spread of rumors and misleading reports. Groups to receive special information pertinent to their needs to include politicians, newsmedia, industry representatives and communities affected by industrial pollution.

Statement of Verification

Upon the invitation of the Human Health Committee of the Alberta Government-Industry Acid Deposition Research Program, the persons on the attached list participated in a workshop held in Banff, Alberta from January 22 - 27, 1984. In the opinion of the undersigned, who were present at the conclusion of the Workshop, the proposed program will meet the objectives of the ADRP — Human Health Effects. The balance of the participants were not present at the end of the Workshop. They will receive copies of this document for review and approval.

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5. Comments on Experts' Recommendations

The Human Health Committee recognized that the experts' recommendations may not be self-explanatory in certain areas. To facilitate their interpretation and subsequent implementation some explanatory comments are provided below. A concerted attempt has been made not to bias the meaning or intent of any of the experts' original statements.

With regard to the Introduction on page 30 the expert advisors concluded that public health complaints represented a valid starting point in defining the nature and magnitude of environmentally-related health problems in Alberta. Although no specific geographic locale was identified for a comprehensive medical diagnostic review, most of the discussions centered around the Pincher Creek/Twin Butte area because of the existence of more health-related information. The Committee therefore feels that this area is implied as a priority one for a diagnostic review. The experts felt that this review "should be accomplished at the earliest possible time, even prior to the initiation of proposed research studies". No protocol was suggested for this study.

The results from a diagnostic review should provide an answer to the question "Is there a problem?" and thus is one essential starting point for the human health component of ADRP. The results from such a study would logically lead to either a discontinuation of further human health research within ADRP or to a cross-sectional epidemiological study designed to test whether the incidence of a specific health effect (e.g., cancer, altered immunological response) occurring in the Pincher Creek/Twin Butte area is significantly different from the rest of Alberta.

As indicated on page 30 the selection of control communities for a cross-sectional community epidemiology study would be based on emissions data, atmospheric models and monitoring data provided by the biophysical component of ADRP. This should *not* be interpreted to mean that this study could not proceed until all presently proposed biophysical projects are completed since these projects, in the present form, would not provide all the information necessary. For example, continuous and extensive *indoor and outdoor* environmental monitoring of a variety of emissions would be necessary to determine both the degree and pattern of residents' exposure. It is anticipated, therefore, that this requirement would place considerable additional demands on the Biophysical Group in terms of study design as well as equipment and resources required.

In addition to community-based epidemiological studies, occupational epidemiology studies were also recommended. The rationale for this is based on a number of factors including:

- better estimates of personal exposure levels
- better techniques for measuring exposure levels
- more episodic exposures
- greater probability of identifying unusual health complaints.

Results from both retrospective and prospective studies would be useful in identifying health effects that may be expressed in the community at large as a result of exposure to acid-forming emissions. Thus, occupational studies may be conducted before or simultaneously with community studies.

As indicated on page 31 human biological monitoring and screening would be used on both community and occupationally-based epidemiological studies. It is important to emphasize that the selection of parameters to be monitored (e.g., tissue metal concentrations; enzyme activities) will require careful selection to improve the chances of elucidating the casual relationship behind a health effect of interest. It is not satisfactory to merely report on altered physiological level of some parameter without providing a plausible explanation of its biological significance. Failure to do so increases the risk of misinterpretation of research findings to the public. This, in turn, raises public anxiety unnecessarily.

One area where biological monitoring was seen to be important in assessing causal relationships was the nutritional status of people exposed to environmental agents. It was noted that nutritional deficiencies may elicit clinical symptoms that would otherwise go undetected in a well-nourished individual. Hg, Cd, Se and Cu are of specific interest in this regard.

In reference to the Methods Assessment section on page 31 it is a basic tenet of high-quality scientific research that all analytical methods be thoroughly evaluated prior to their use to ensure their:

- appropriateness
- sensitivity
- precision
- accuracy

One point stressed at the workshop was that fully accredited laboratories be used in performing biological/physical sampling and subsequent quantitative analysis. It was recognized that this was often the most costly part of scientific research yet the area where the greatest source of errors and subsequent erroneous interpretations can occur.

In approaching the characterization of emissions from various point sources the experts recommend that further effort be expanded to characterize major emission sources for chemical constituents that have not been previously identified and which could adversely affect health. This would include:

- metals (e.g., Pg, As, Hg, Cd, Fe, Cu)
- sulphur compounds (e.g., CS_2, COS, dimethyl sulphide, mercaptans)
- flare emissions
- raw sour gas

and would extend to the plant site, the individual residence as well as the general environment.

In Section II (Clinical Service and Field Research Programs) on page 31 the experts provided four recommendations to "address additional needs in the area of environmental health" problems in general. In making these recommendations the expert group was not suggesting the outlay of considerable capital expenditures. On the contrary, the general feeling was that the organizational structures into which these recommendations may fit probably already exist in Alberta.

In the first case it was recognized that environmental health complaints tend to be recurring in nature. In order to be able to more accurately correlate public health symptoms to episodes of environmental pollution a continuous toll-free "hot line" was recommended. This system would simply log complaints and refer those that required further medical follow-up. One example of such a system exists in Rotterdam. No specific site was suggested for this "hot line".

The second recommendation recognized the need for a central repository of all relevant information that is or has been collected by government agencies, industries or public groups. The collection of this information in one place would facilitate coordination of research activities in the province as well as the design of future health studies. Again, no specific site was suggested.

The third recommendation addressed the need for a medical unit that could deal with individual environmental health complaints requiring specialized "medical diagnostic evaluation and care". Often the diagnosis of an environmentally-related health complaint is very difficult without specialists trained in this area. The formation of such a unit with one or more environmental health physicians would be a logical receptacle for complaints coming directly from the community or indirectly by referral from government agencies or private industry. The obvious site for such a unit would be a university hospital. One of the key roles of this unit would be community education about environmental health issues.

The final recommendation in this section addresses the need for the establishmnet of a multidisciplinary field investigative team that could respond to unusual pollution episodes. Although a fixed membership on this team is implied, the Committee concludes that the composition of a team may vary according to the specific pollution episode. Since the health of community residents would be assessed, it is likely that the core of this team would be attached to the environmental health medical referral unit. Other members would likely be drawn from a pool of recognized experts on an as needed basis.

Taken together the above four recommendations would involve considerable interaction and coordination of activities between interested parties.

In Section III (Human Clinical Research and Animal Toxicology) on page 32 both human clinical and animal toxicology studies were recommended. In order of priority the human clinical studies were deemed more important initially in defining the end points to assess in animal studies. This was anticipated to take the first two to three years of the human health program. Having specified end points, animal toxicology studies would be designed to assess the acute, subchronic and chronic toxicity of different pollutants, alone and in combination and thus provide new knowledge about the potential toxicity of these compounds in humans. Simultaneous human clinical studies may also be conducted but at much lower exposure levels.

In Section IV (Behavioral Environmental Health Issues) on page 32, the expert group has attempted to deal with the important influence of public perception of health as it is related to exposure to acid-forming emissions. It was recognized that this area is commonly ambiguous and complex and can influence the manner in which health complaints are reported. This, in turn, may influence considerably the research strategy that is employed to resolve an environmental problem. At one end of the spectrum a real problem may be resolvable by the scientific approach. At the other end, if the problem is largely perceived and not real, the application of a scientific approach may prove futile. It is important, therefore, to have a good understanding of those factors that affect individuals' perceptions of the health effects of atmospheric pollutants over time.

In the final section (Organizational Principles) on page 33 some recommendations were offered for setting up the human health component of ADRP. The most important recommendation is that of a Scientific Advisory Body (SAB). It is a basic principle of a scientific research that rigorous *external* peer review is necessary to ensure quality control of research study design, progress and results interpretation. Most research programs have such a system in place. This not only provides a measure of public credibility but also helps focus limited research dollars on the most important projects.

The composition of the SAB could include Alberta scientists providing they are independent and internationally renowned. Otherwise external experts would be used.

With regard to the "Referral System" on the same page, it was recognized that in any community or occupational health study "previously undetected disease" may be uncovered as a result of ADRP activities. The expert group recommended that a plan is necessary for dealing with such cases. For straightforward cases this could be provided through local hospitals. However, for difficult cases of obscure origin, referral to an external, specialized medical centre (e.g., Mayo Clinic, Rochester, Minnesota) may be appropriate. In such cases a plan is necessary for dealing with the additional costs incurred by such a referral.

Finally, there was considerable discussion at the workshop regarding community liaison. It was recommended that public representatives be "fully

credited members of all standing committees connected with the" ADRP. Increased public awareness and credibility are two obvious benefits of the recommendation. No suggestions were made for selecting "public" representatives or what level of input they would have. It was recognized, however, that in some cases public input may contribute significantly to the design of the research project whereas in others it would be minimal. It was felt by many the ultimate responsibility for the design of scientifically acceptable studies lay with the scientists.

Of particular interest in this section is the recommendation that *only* peer-reviewed information be released to the public. The reason for this was to "contain the spread of rumors and misleading reports" based on misinterpretation of unreviewed data.

Although no sequence of information release was suggested, it was recognized that certain groups (e.g., politicians, industry, news media and affected communities/work sites) would likely have special needs for the information which should, therefore, be released on an equal basis so that political and industrial concerns do not supercede those of community residents.

6. Implementation of Expert Recommendations

The value of any set of recommendations generated by a scientific advisory group is in how far they go to resolving the specific problem at hand. Implementation of such recommendations must take into account several factors including:

- potential impact (positive or negative) on major stakeholders
- feasibility — in terms of time, cost and manpower.

In general, the Human Health Committee feels that the workshop recommendations will provide the necessary answers to key research questions of interest to ADRP. In fact, if implemented in total, they will far surpass the mandate of ADRP since they provide a blueprint for a general approach to the resolution of environmental health problems arising in association with natural resource development in Alberta. This approach is applicable to other resources (e.g., oil sands, coal).

The singlemost important recommendation in this workshop is the call for the establishment of a scientific advisory body (SAB). The Committee feels that this recommendation is critical to the success of ADRP both from public credibility and quality control perspectives.

Recommendation

> The Human Health Committee recommends the complete adoption of the expert recommendation outlining "Scientific Control of the Program" (page 33) by both ADRP and any government agency, industry or public group interested in resolving environmental health questions through the scientific approach.

In approaching the Banff workshop recommendations it is important to recognize the uniqueness of the event and to understand the meaning of the total recommendations package since it represents a complete and valid response by the expert advisors to the question posed at the workshop. This does not imply that their implementation is based on an "all or none" philosophy, only that anything less than a full review prior to implementation will increase the likelihood of fragmenting and diluting their overall potential benefits.

The Committee recognizes that some aspects of the workshop recommendations could be undertaken by different government departments and/or industry. However, this would only be advisable if they also subscribe to the principle of external scientific review elaborated on above. This, of course, will require the commitment of the respective senior executives of these organizations.

In addition, considerable care must be taken to resist the temptation to rush into health research studies because of public or political pressures. It is essential that all health-related research conducted within ADRP be well planned, well integrated and properly communicated to the affected parties because of its complexity and sensitivity.

With regard to the design of scientifically-valid research studies the expert advisory group recognized a lack of appropriate expertise in Alberta of certain essential disciplines (e.g., toxicology, epidemiology) required for some of the proposed research. The Committee feels that this reinforces the need for an SAB that would critically review the design, progress and results of health studies. It is noteworthy that several of the expert advisors would be willing to particpate in this or some other related capacity.

Administration of ADRP Projects

The experts discussed the organizational structure of ADRP at some length. The need for an informed administrative component was recognized: one which was familiar with project management and which would establish good working relations with both the Members' Committee of ADRP and the SAB. The administrative unit would have to deal with a wide range of experts on SAB and an even wider range of expertise carrying out the research.

Recommendation

> The Human Health Committee recommends that the Scientific Advisory Body (SAB) be chosen from experts who have already been involved with the ADRP workshops and that the program be administered, initially at least, by the respective technical committees, until such time as the work load proves too excessive.

Advantages of the Recommended Option

The advantages of the recommended option are:

1. Considerable time and effort were expended into developing an information base on research into acid forming emissions and their effects in Alberta. This option takes advantage of that information base.
2. A considerable amount of time was spent informing the experts about the Alberta situation. It is cost-effective to select some of those experts already knowledgeable in this area to form the SAB.
3. The experts already worked together for five days discussing the problems surrounding acid forming emissions and their effects. This option will take advantage of an existing working arrangement.
4. The experts are sensitive to the Alberta situation and many are willing to actively participate in ADRP.
5. The experts are highly qualified and independent.
6. The committee members are already familiar with this program.
7. The committee members from both industry and government have demonstrated the ability to work together.
8. The committee members have developed a working relationship with the experts.
9. Committee members were present during the entire deliberations of the experts. This type of experience cannot be duplicated or substituted.

Alternatives

As the recommended alternative is in two parts, other alternatives are discussed separately to avoid the unnecessary duplication of various combinations of the two.

a) *Scientific Advisory Body*

1. *Not to have one.* The only merit to this alternative would be the saving of simple fiscal costs which would be far outweighed by the credibility problems generated.
2. *Bring in experts who were not involved in the workshops.* This is not cost-effective in terms of informing them about the specifics of the Alberta situation. It has merit in providing a second scientific opinion but that may be seen as unnecessary duplication.

b) *Administration*

1. *Not appoint one.* The research program must have an administrator. Not to appoint one would require the services of an administrator on a voluntary basis from either industry or government. This may be cost-effective, but it may also be inconvenient. Coordinating a volunteer may not be conducive to producing the best product from the program.
2. *Appoint a part-time administrator.* A person who is a fully-qualified administrator in terms of research management, dealing with RFP's and taking directions from SAB, may not be readily available. A part-time administrator will not always be available at the best time to suit ADRP or SAB.
3. *Appoint a full-time administrator.* Not warranted by the initial level of activity in the program.

7. Proposed Projects

A review of experts' recommendations was given earlier. Careful analysis of these recommendations reveals that the proposed activities in the human health area may be divided on the basis of natural groupings, dependency, and priority. These divisions are shown in the attached chart.

Referring to the attached chart, it should be noted that the groupings in the first column (1984-85) may be altered by further expert input. At present, the proposed activities in column two (1985-86) and beyond are dependent upon results from activities in 1984-85. If such results are not forthcoming, that particular line of enquiry would likely cease. Hence, the activities recommended beyond 1985-86 would not begin until results were obtained from activities in column two.

The Medical Diagnostic Review (MDR), which is not contained in the enumerated list in the Executive Summary, entails going into the field with a team of medical experts that will enquire after ill-health symptoms of a long-standing nature. This will produce reports and documentation of symptoms that may be attributable to acid-forming emissions or other causes. This project ideally requires that the medical referral unit (2.c) be set up at the same time as MDR so that the referral unit staff may share or participate in the acquisition of environmental versus health effects data as the research project proceeds. The staff would also deal with cases requiring immediate medical attention.

The initiation of these activities in environmental health should also ideally entail the initiation of a central repository of data (2.b). An occupational epidemiological study of moderate and high level exposure victims should be initiated early to identify points that may be worthwhile studying in the community at large. This project would begin with a historical review of known exposure victims. From this a cohort would be defined to follow prospectively. Thus, the MDR, the referral unit (2.c), the data repository (2.b), and occupational epidemiology (1.b) form a more or less natural group of proposed initial activities.

The next group of projects that may be readily identified is based on those proposals that address the response to emergencies and the ongoing collection of baseline data. This is composed of a community input program using a toll-free "hotline" (2.a) and a field investigative team (2.d). Not so obviously, odour investigation (4.b) may also be a member of this group. It is not always possible to properly investigate odour if you have to rely on individual recall but a study protocol has to be ready for implementation when the next emergency occurs.

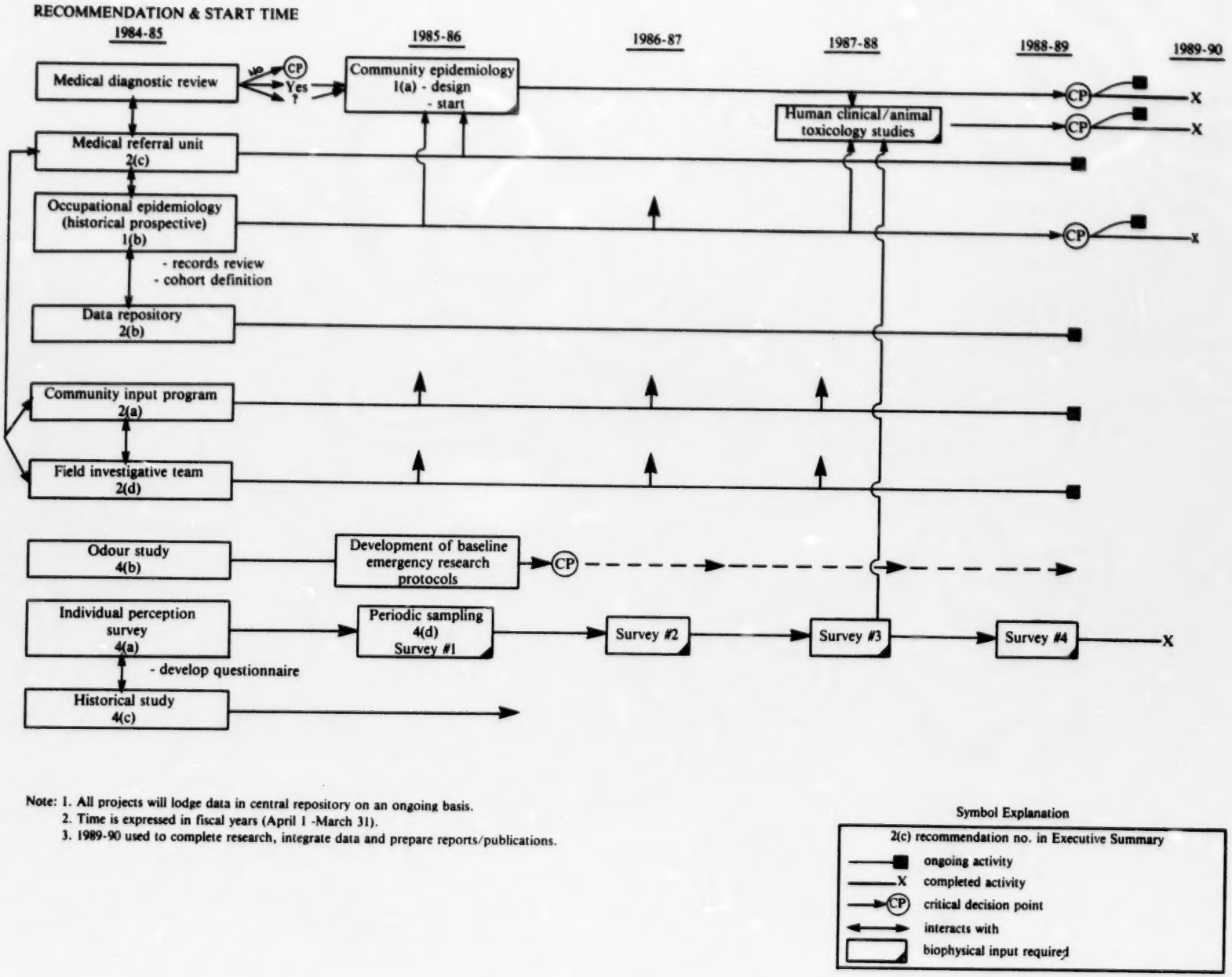
The last group in column one consists of two recommendations from Behavioral-Environmental Issues — survey of individual perceptions (4.a) and an historical study of factors leading to community conflict (4.c). These should both precede the periodic sampling (4.d). These studies will indicate where the public perceives the priorities to be and what specific issues it has concerns for. This information will assist decision-makers within ADRP in identifying priority research areas. It may also contribute to the specific design of research studies.

As to the timing of the implementation of the activities in column one, the experts recommended that the MDR had immediate urgency and the occupational epidemiology (1.b) has high priority as well. It seems fairly obvious that the planning of the protocols which address the response to emergencies should also receive high priority. The two recommendations in the last group may only be implemented when timing with respect to public response is optimum. For example, a survey of individuals' perceptions about environmental matters should not be attempted while E.R.C.B. Lodgepole hearings are taking place and the media reports contrary views almost daily. It is likely to distort the public's normal opinions about the environment. If the design of the historical study (4.c) does not involve direct personal input by the public, however, it may be started anytime.

Once the initial projects are started most will continue to 1989-90 or beyond. Critical decision points have been indicaed on the chart.

It is important to note that proposed health projects requiring Biophysical Group input seem to integrate well from a temporal point of view with the proposed Biophysical Research Program. For example, some of the essential atmospheric data for a cross-sectional community epidemiology study will be available in 1985-86, the year this project would begin.

Also noteworthy is the interaction between key research projects. For example, data from occupational epidemiology study, a community input program, an odour study, perception survey and historical study would be useful inputs to a community epidemiology study.



Note: 1. All projects will lodge data in central repository on an ongoing basis.
2. Time is expressed in fiscal years (April 1 -March 31).
3. 1989-90 used to complete research, integrate data and prepare reports/publications.

Symbol Explanation

2(c) recommendation no. in Executive Summary

ongoing activity

X completed activity

CP critical decision point

interacts with

biophysical input required

APPENDICES

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May 28, 1983 - Edmonton Journal - No closure of gas plants.

May 28, 1983 - Edmonton Journal - Bishop upset by way study announced.

May 28, 1983 - Calgary Herald - Sour gas study snubbed.

May 31, 1983 - Calgary Herald - ECA asks Webber for full health study.

May 31, 1983 - Edmonton Journal - Sour gas inquiry 'not needed yet'.

June 4, 1983 - Calgary Herald - Residents are sure sour gas to blame.

June 13, 1983 - Alberta Report - Medicine, Sour gas: a whiff of danger.

June 21, 1983 - Globe and Mail - Alberta study fails to clarify argument on gas-plant perils.

June 28, 1983 - Edmonton Journal - Widespread health concerns surround gas plants - expert.

June 29, 1983 - Calgary Herald - Pollution policing reviewed.

June 29, 1983 - Calgary Herald - 'Social excitement' colored feelings about blowout.

July 5, 1983 - Red Deer Advocate - Full study sought of gas plant illnesses.

July 5, 1983 - Lethbridge Herald - Sage Institute wants a Pincher illness study, too.

July 13, 1983 - Claresholm Local Press - Gas plant findings at Pincher Creek and Twin Butte.

July 17, 1983 - Edmonton Journal - Sour gas coalition warned about panic.

July 20, 1983 - Rocky Mountain House Mountaineer - Warning issued to sour gas group.

July 22, 1983 - Calgary Herald - Shell denies emissions linked to illness.

August 1, 1983 - Calgary Herald - Sour gas plant protested.

August 13, 1983 - Calgary Herald - Dead fish dumped to protest gas plant.

August 15, 1983 - Edmonton Journal - Definitive Pincher Creek study sought.

August 16, 1983 - Calgary Herald - Greenpeace set for fight on gas.

August 16, 1983 - Edmonton Sun - Alberta to probe Lodgepole fatality.

August 16, 1983 - Edmonton Journal - Inquiry date set in sour gas well capping death.

August 17, 1983 - Edmonton Sun - They blew it: Amoco.

August 19, 1983 - Journal - Media 'distorted' wild-well dangers.

August 20, 1983 - Globe and Mail - Gas is first target of Greenpeace group.

August 22, 1983 - Edmonton Sun - Amoco's big stink.

August 24, 1983 - Fort McMurray Express - Shut down - and Sulphide risk.

August 26, 1983 - Edmonton Journal - Inspectors: well blowout potential risk.

August 30, 1983 - Edmonton Sun - Death still a mystery.

August 30, 1983 - Edmonton Journal - Workers died despite safety measures.

August 30, 1983 - Calgary Herald - No light shed on well deaths.

August 30, 1983 - Journal - Wild well deaths still a mystery.

August 31, 1983 - Edmonton Sun - Amoco inquiry hears expert, A mask of death?

August 31, 1983 - Edmonton Journal - Masks may have led to wild-well deaths.

September 2, 1983 - Calgary Herald - Deaths linked to gas masks.

September 6, 1983 - Calgary Herald - Amoco outlines its version of blowout.

September 8, 1983 - Edmonton Journal - Alberta among the best for pollution control.

September 20, 1983 - Calgary Herald - Health study is urgently needed.

September 30, 1983 - Edmonton Sun - Amoco blowout made people sick.

September 30, 1983 - Edmonton Journal - 76% in rural area ill during blowout.

October 3, 1983 - Edmonton Journal - Lodgepole wasn't a bad dream.

October 17, 1983 - Edmonton Journal - Blowout drills neglected — report.

October 17, 1983 - Edmonton Sun - Lodgepole study completed.

October 17, 1983 - Edmonton Journal - Sour gas plant review needed - workshop.

November 2, 1983 - Edmonton Journal - Gas blowout hazard-free, says Amoco.

November 2, 1983 - Edmonton Sun - Amoco ducking cross-examination: lawyer, Inquiry turning into a 'farce'.

November 6, 1983 - Edmonton Sun - The big stink blows again.

November 18, 1983 - Edmonton Journal - Study clouds link to disease.

November 22, 1983 - Calgary Herald - Gas blowout not to blame for sickness.

November 24, 1983 - Calgary Herald - Woman suffered trauma.

November 24, 1983 - Calgary Herald - Panel wrestles with crucial call.

November 24, 1983 - Edmonton Journal - Lodgepole inquiry told of ill health.

November 24, 1983 - Red Deer Advocate - Blowout residents 'used as guinea pigs'.

November 30, 1983 - Drayton Valley Western Review - Informal inquiry draws well.

December 5, 1983 - Edmonton Journal - Drayton Valley deserves better.

December 9, 1983 - Calgary Herald - Turnout slight for Lodgepole health session.

December 9, 1983 - Lethbridge Herald - Only five complainants express views at Lodgepole hearing.

December 13, 1983 - Red Deer Advocate - Inquiry raises questions about sour gas emissions.

December 15, 1983 - Calgary Herald - Sour gas 'not cause of illness'.

December 16, 1983 - Edmonton Journal - Offended isn't same as sick, says Amoco president.

December 16, 1983 - Edmonton Journal - Journal writer remiss on blowout facts, inquiry told.

December 16, 1983 - Calgary Herald - Safety measures increased after well deaths.

December 24, 1983 - Edmonton Journal - Public wants answers on health effects of blowout.

December 26, 1983 - Alberta Report - Anatomy of a blowout, Acrimony sours the Lodgepole probe.

December 29, 1983 - Calgary Herald - MLA faults public, media.

January 2, 1984 - Calgary Herald - Blaming media easy.

Video Reference Material

Human Health Workshop

Banff Springs Hotel

Banff, Alberta

January 23 - 27, 1984

CFCN - Calgary - Fugitives on the Wind.

Blowout at Lodgepole, The Story by Amoco (E.T. 65 minutes)

CITV TV November 17, 1982 10:03 p.m. (E.T. 2:45)

CITV TV November 17, 1982 10:06 p.m. (E.T. 1:20)

CBC TV December 12, 1982 5:10 p.m. (Eve Savery)

COMMUNICATIONS WORKSHOP

May 1984

Background

On April 30/May 1, 1984, the ADRP held a "Communications Workshop" at the Chateau Airport, Calgary, Alberta.

The intent of the workshop was:

To determine what should be done to communicate ADRP's purpose, concerns, activities and research results to the Alberta public. Specifically:

- Identify effective means of informing various publics (industry, government, media, special interest groups, affected communities and the general public) about ADRP and, on an ongoing basis, about ADRP research projects and results.
- Identify means of involving these publics in the work of ADRP.
- Suggest appropriate communications mechanisms for delivery of ADRP information to the public.

About forty individuals participated in the workshop. They represented a wide variety of professional talent in the communication field and included representation from the provincial government, the Alberta energy industry, special interest groups, the media, the Energy Resources Conservation Board, public participation consultants and individuals from the ADRP Members Committee.

On the morning of May 1, 1984, some 20 persons from the previous day's workshop gathered to discuss and add input into the planning of a general document to be known as "Public Involvement and Communication" a report on the Calgary communication workshop.

Originally, the workshop was designed to prepare an umbrella strategy for communication to the public of the goals and purpose of the ADRP and its research projects.

However, during the workshop it became abundantly clear the subject of direct public involvement was of equal concern to that of general communications.

As a result, it was a necessary conclusion that any communication strategy must take into consideration the vital role of public participation, with the final product reflecting widely beyond traditional communication practices.

It was a general view that for ADRP to be successful and to receive public endorsement, the parallel roles of public involvement and good communication practices could not only serve the Program well, but may lead to a better "quality" of the end result (the Program).

Because the public involvement issue emerged as such a dominating influence during the workshop, an emphasis has been placed on this subject in an attempt to integrate the public involvement element into total communication planning.

No reference was made to the cost of a communication plan. Accordingly, participants offered a wide-ranging spectrum of ideas which the workshop moderator developed into a work plan proposal.

In point form, the following are the workshop's suggested objectives, strategies and other recommendations.

Advantages of a Public Involvement/Communications Program

- It has the potential to turn around the present perceived negative image.
- It gives the general public and interest groups the opportunity to respond constructively to the work of the scientific workshops.
- It can create a public and scientific acceptance of ADRP's research program.
- It fulfills the expectations raised in the communications workshop.
- It provides the basis for a seven year program of public involvement.
- It puts the ADRP in public view on a continual, patterned basis.
- It sets the stage for dealing with "sensitive" research findings.

Inform/Involve: Principles for Success

Public Involvement: A Definition

People must see the process as dealing with the issues that are important to them and, must feel they can influence decisions through (their) involvement.

Communication: A Definition

Communication is the intent and ability to translate the purpose, aims and concerns of an organization/program into terms understandable to other groups and to the public at large.

Quality: A Definition

Through public involvement and communication, quality means improvement in the planning process — and in particular, the end result of a project or program.

Mission Statement

Trust, Confidence and Quality

The primary purpose of a communication strategy is the establishment of trust, confidence and quality through positive measures that allow effective public involvement and participation; and a firm commitment to the timely dissemination of information to the general public.

Acid Deposition Research Program

***Objectives (Revised)**

1. To provide a comprehensive understanding of the effects and consequences of acid-forming gases on the environment;
2. To provide a scientific basis for sound, long-term environmental management and regulatory control with respect to acid-forming gases;
3. To disseminate information to the public, to government bodies and to industry;
4. To encourage and include opportunities for public representation in the ADRP;
5. To undertake any research deemed appropriate;
6. To form recommendations and/or suggest action, if necessary, as a result of the findings of the scientific research projects.

**From the Charter, Acid Deposition Research Program January 1983, page 2; items 4 and 6 added.*

ADRP Public Involvement and Communication Objectives

1. To disseminate to both general and specific publics information about the purposes, goals and research finding of the Acid Deposition Research Program.
2. To provide opportunities for two-way communication for public involvement/public representation in the ADRP; and on the Members Committee.
3. To establish program review channels for public response and comment.
4. To circulate specific information resulting from ADRP research studies to the scientific community, media, special interest groups and affected communities.
5. To inform and educate the public accurately about known effects of acid-forming emissions; and to impress upon the scientific community the importance of information programs as a means of public education.
6. To enhance public, scientific, government and industry acceptance of the ADRP.

Strategies for Public Involvement and Communication

(A) To take advantage of all practical opportunities to inform the public, media, special interest groups, the local scientific community and affected communities about the goals, objectives, purposes and technical studies of the Acid Deposition Research Program.

(B) To make provision for reasonable public representation on the Members Committee of the ADRP; and to incorporate into the program appropriate channels and systems for public review with the purpose of receiving and responding to input from the public.

(C) To identify means whereby government, industry, special interest groups and the public, working together, can be informed for the purpose of providing a comprehensive understanding of the effect/s of acid-forming emission gases on the environment.

(D) To highlight the critical objective that public involvement (PI) and communication planning (CP) are equally important to the success of the ADRP and its research projects as are the technical/scientific studies; by linking as closely as possible PI and CP to the research program with the clear understanding that neither PI nor CP can or should compromise the scientific nature of the ADRP research program.

(E) To create in-place structures and implement planned communication programs for the timely release of information about ADRP and its research results.

(F) To increase the public profile of ADRP through public education programming combined with traditional informational practices.

(G) To define the circumstances and/or limitations of the role/s of the public representative/s, the project scientists/technical people and officials within government and industry (who are not delegated as spokespersons) to comment or make public pronouncements on the ADRP or to accept media interviews concerning the Program.

(H) To set up systems to monitor and evaluate public involvement and the communications plan.

(I) As an interim measure, to develop a public involvement/communications plan related specifically to the release of the early elements of the scientific research projects.

Public Involvement — A definition

Public involvement means creating mechanisms that allow the public:

- to have effective representation within the highest policy and planning structures of ADRP;
- to be able to add community/local input, response and influence into the long-range strategies of the program and its various research projects;
- to be kept informed about the Program, its progress and research results.

Recommendations

- At the present time, the Members Committee includes as "observers" a public representative and a representative of the ERCB. It is suggested

the "observer" status be re-classified to "non-voting" representation on the Members Committee; and that public representation on the Members Committee have provision for at least two public representatives (not including the ERCB).

- The creation of a Public Advisory Board (PAB). This board would draw members from special interest groups such as the Public Advisory Committee of the Environment Council of Alberta, the Sour Gas Coalition and so on. The public representative/s on the Members Committee would be member/s of the PAB.
- A public representative on the Members Committee would be the chairperson of the PAB. This person would act as liaison between the PAB and the Members Committee for the purposes of exchanging information and to channel input to/from the PAB and the Members Committee.
- This public representative would also arrange, at the request of PAB membership, meetings of the PAB members-at-large with the Members Committee for direct communication and review of the research projects of ADRP, when the members-at-large felt this was necessary.
- Develop a mailing list for special interest groups, (affected) community leaders, and the media, for the purpose of distributing the technical research results and other information of a general and/or detailed nature.
- That as a means of public feedback on the research projects and/or their results, a "flyer" be prepared for inclusion, with or attachment to or to include with or attach to the released material/s allowing recipients to respond with their comments; and for the ADRP communications office to set up a system of acknowledging the replies.
- Especially where required by research needs, that from time to time the ADRP Members Committee hold public meetings/workshops in communities in Alberta to inform the public about the subject of acid-forming emissions and report on the progress of the ADRP; and to solicit public input and comment.
- That the public representative/s and/or others be able to comment publicly and in a reasonable (constructive) fashion about ADRP.
- That ADRP allow reasonable public/media access to information about ADRP, its meetings and programs.

Communications

Recommendations:

- ADRP should establish a Communications Office with appropriate staff and budget. The Communications Office would become an institutionalized function of the ADRP, and be part of the Program administration.
- The Members Committee should appoint a Communications Advisory Committee reporting to the Communications Office. This committee would consist of the "Team Members" from the April 30, 1984 Communications Workshop. It would meet from time to time to monitor and evaluate the Public Involvement and Communications program.
- The Communications Office should have its own identity, telephone number, address, and if necessary a "hotline".

The Functions of the Communications Office/Officer Would Include:

- To disseminate information to the general public (about the goals, objectives and programs of ADRP).
- To respond to inquiries from the public, the media and others about/for information on ADRP.
- To prepare educational materials about the work of ADRP.
- To arrange for the timely release of research results relating to ADRP.
- To prepare media releases, newsletters, arrange for media interviews, plan and organize news conferences, public workshops, community meetings and other communication vehicles, as directed by the Members Committee.
- To organize an in-house reference library to include publications, news clippings and other relevant information on ADRP.
- To undertake special communication projects, as directed by the Members Committee.
- To prepare surveys, questionnaires etc. relating to public perception of ADRP, as directed by the Members Committee.
- Where deemed necessary, to establish liaison with special interest groups.
- To prepare, as directed by the Members Committee, an ADRP Annual Report.
- As directed by the Members Committee, the Communications Office will undertake all or any forms of communication to inform the public, special interest groups, government and/or its agencies, and industry about the goals and purposes of ADRP.
- To identify conditions which may tend to generate local concern; and to respond accordingly.
- To organize special occasions where public interest groups, community leaders and the media may have an opportunity for field trips to observe on-going research projects.
- To explore the possibility of developing an educational program, for use in the school system, relating to acid deposition (perhaps in conjunction with the Rural Education and Development Association).

- Depending on financial considerations, to prepare an advertising campaign strategy.
- To attend Members Committee meetings as an "observer"; and in matters of a general but non-technical nature to act as ADRP contact/spokesperson with media and other publics.

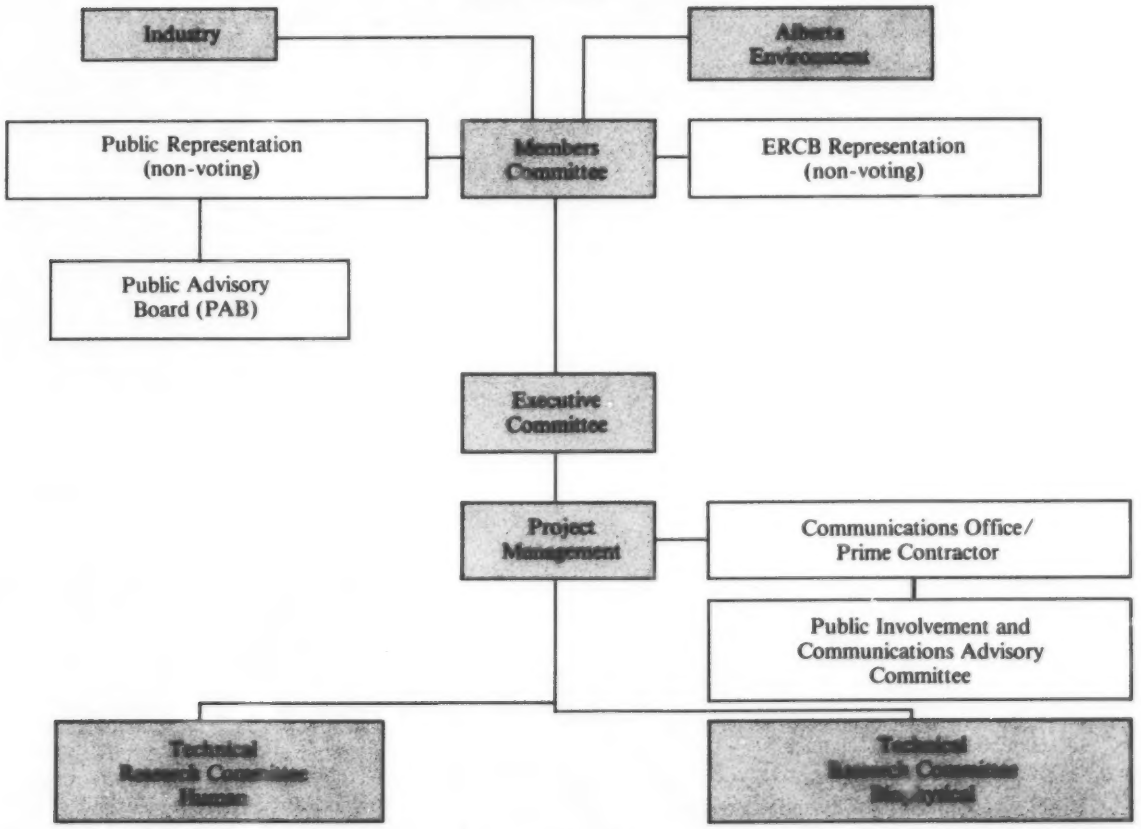
The Scientific Community

Recommendations

Scientists and other technical experts working on ADRP projects should be made aware, notwithstanding (their) substantial and justifiable reasons for caution, that elements of public communication may be necessary for the successful completion of the projects and the building of public confidence in ADRP.

- Measures should be taken to assess and perhaps to develop guidelines wherein it would be reasonably expected for technical experts working on the research projects, to make public comment or to accept media interviews on the progress of their work or following release of their material. In all cases, public comment must meet the objective "that the scientific nature of ADRP research projects shall not be compromised."

Alberta Government/Industry
Acid Deposition Research Program
Proposed Reorganization



MEMBER REPRESENTATIVES:
Alberta Environment } Co-Chairmen
CPA
IPAC
Petrocan
Nova
Utilities
ERCB
Public representative } non-voting

EXECUTIVE COMMITTEE:
Alberta Environment } Co-Chairmen
Industry (CPA)
Secretary
Treasurer

TECHNICAL COMMITTEES:
Industry } Co-Chairmen
Government

Existing Organization

Proposed Change

Workshop Participants

Mr. John K. Bales
Energy Resources Conservation Board

Mr. Ed Brushett
Energy Resources Conservation Board

Mr. A.W. (Ab) Campion
The Houston Group Communications

Ms. Wendy Carpentier
Pincher Creek Environmental Coalition

Dr. Dave Chisholm
Shell Canada Resources

Mr. Jim Dau
Alberta Social Services & Community Health

Mr. John Eisenhauer
Alberta Wilderness Association

Mr. Ron Findlay
Amoco Canada Petroleum Co. Ltd.

Ms. Susan Hall
Hall & Associates

Dr. Martha Kostuch
Veterinarian

Dr. George Kupfer
Fresh Start Social Consultant Co. Ltd.

Mr. Elmer Kure
Alberta Fish & Game Association

Mr. Jerry Lack
Alberta Environment

Mr. Toby Lawrence
Alberta Energy & Natural Resources

Mr. Mark Lowey
Calgary Herald

Mr. Rob MacIntosh
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Mr. Peter McKenzie-Brown
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Environmental Protection Agency

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Mr. Gordon Ward
Association of Municipal Districts and Counties

Ms. Susan Washington
Banff Centre

Dr. R. Westbury
SEEDS Foundation

Mr. Norman White
Unifarm Association

Mr. Millard Wright
Gulf Canada Resources Inc.

POOR

QUALITY

ORIGINAL